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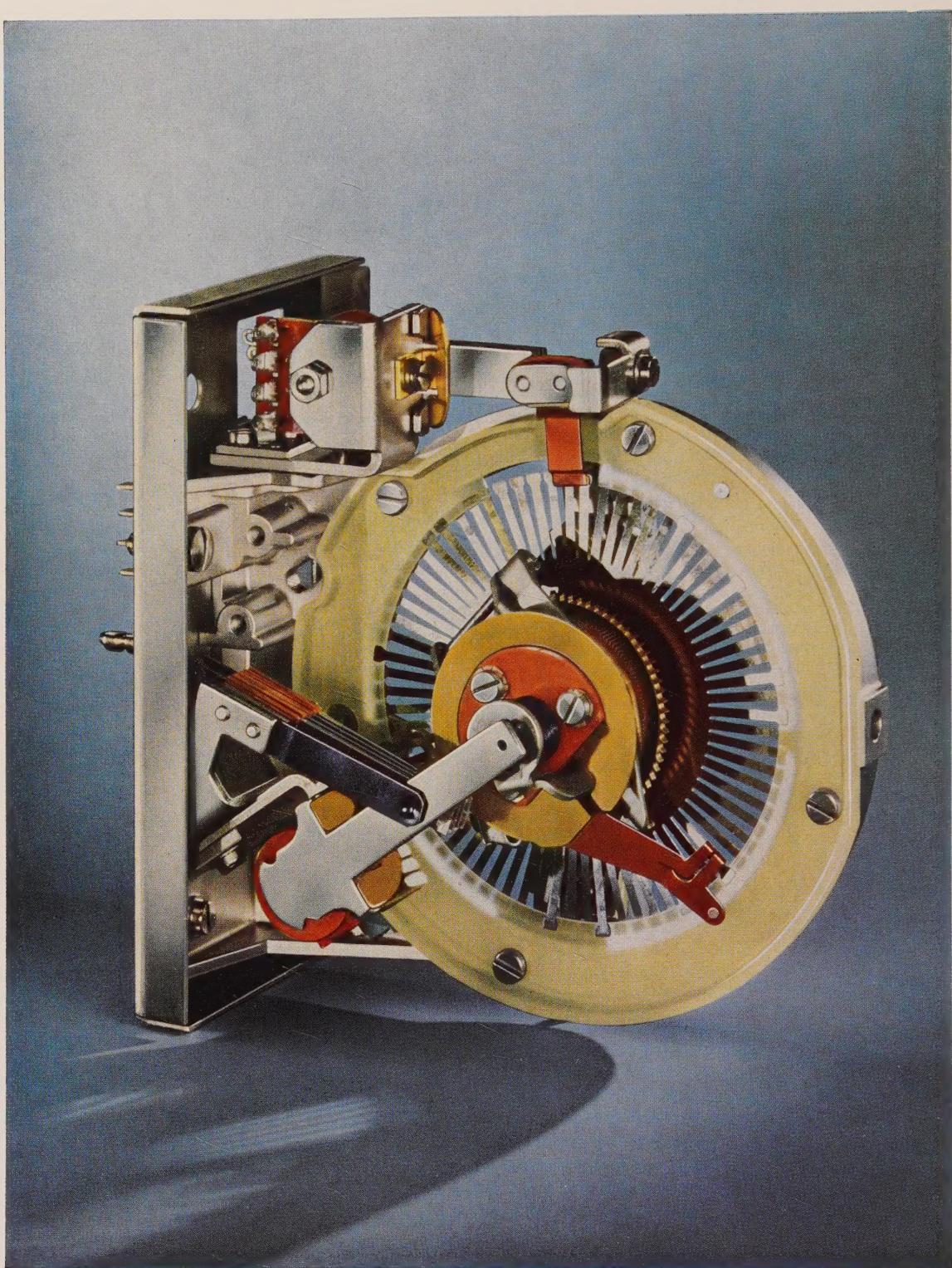
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Designed for the simultaneous storage and retransmission of dial pulse trains in dial systems, mechanical dial pulse repeaters offer wide scope in the processing of dialing information and increase reliability in the establishment of connections



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Gandhi Sagar — a New Hydroelectric Power Station in India

BY EBERHARD WOLF FROM

The Chambal project

The Chambal is one of the few rivers in India which flow through the country for any distance in a direction from south to north (Fig. 1). From the northern slopes of the Vindhya hills which extend over a distance of 370 miles from west to east and divide the Ganges Basin from the mountainous country of Central India, the river Chambal flows almost 200 miles northwards before it enters a gorge-like valley of over 60 miles in length at a point 50 miles to the south of Kotah. At the provincial capital of Kotah the valley again widens and the river flows for a distance of 330 miles in a north-easterly direction through level terrain until it enters the Jamuna, the second largest tributary of the Ganges.

The object of the Chambal project is to irrigate a barren area of 2,185 square miles, produce a grain crop of 475,000 tons annually and to generate 210 MW for the power supply of areas within a radius of 200 miles. Another important function of the project is, however, the impounding of the floodwater from the River Chambal which during the rainy season every year swamps the country, often destroying vast areas of cultivated land.

At the present time only about 6% of India's extensive water power potential is utilized for the production of energy. The regulation of the River Chambal thus represents an important step forward in the exploitation of the natural sources of energy in the country and in the further extension of the Indian industry and economy.

The Chambal project comprises a total of four sections. There are three dam stages in which the head of the water is used to advantage for the generation of electrical energy and for an irrigation system. This has a dam main-

ly of the earth-fill type and an extensive system of canals which extends over a distance of about 235 miles on both sides of Chambal to the point where it flows into the Jamuna.

The completion of the entire project on the Chambal will take 15 to 20 years.

Whilst the irrigation dam, located in the immediate vicinity of the town of Kotah, appreciable parts of the canal system and the first dam stage approximately 50 miles upstream have been completed within the framework of the second five-year plan of the Indian Government, the second and third dam stage between the two dam points referred to form part of the construction programme to be carried out in future years.

For the purpose of carrying out the entire project independently, the government has formed its own organization the Chambal-Hydel and Irrigation Scheme, Madhya Bharat.

Among the many firms in Europe and in Japan which tendered for the supply of the hydroelectric equipment for the Gandhi Sagar power station, Siemens-Schuckertwerke, together with J. M. Voith, received orders for the first three generating units. Included in the order for the generators was the auxiliary electrical equipment for the power house and also the 400-V three-phase distribution board for the power-house station-service supply.

The Gandhi Sagar dam Dam works

For the construction of the Gandhi Sagar dam, which is the largest of the four dam works, the entrance of the narrow valley referred to offered extremely favourable conditions. The valley is sealed off by a dam of the

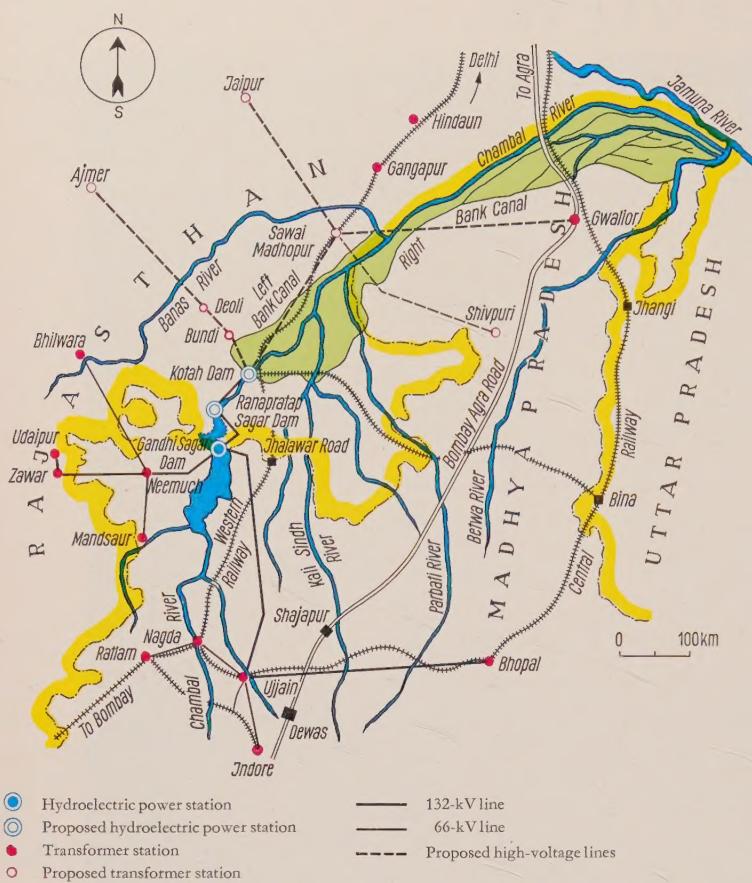


Fig. 1 Location of the Gandhi Sagar hydroelectric power station and other dam stages on the River Chambal (1 km = 0.621 mi)

gravity type which is 1,685 ft. long and 204 ft. high (Fig. 2). With a length of 70 miles and a surface area of 266 square miles the reservoir will have a capacity of 298,400 million cubic ft. The dam with a crest width of 21 ft. will at the same time form the new road over the flooded valley from the railway station Jhalawar Road in the east to the localities of Neemuch Zawar and Udaipur in the west of the Chambal.

For the construction of the dam, use was made of the broken quartzous rock on the steep slopes of the narrow valley, which, together with Surkhi cement, was worked to form a solid wall.

On account of the extremely favourable site conditions, the Gandhi Sagar reservoir is for its capacity one of the cheapest artificial reservoirs in India. Its water capacity is sufficient to maintain four generating units in the Gandhi Sagar power station in operation for two years, even if there should in one year be no monsoon, a condition which arises at fairly long intervals.

Power station

The power house is a long rectangular building (about 310 ft. × 60 ft.) located at the northern foot of the dam in the eastern half of the river bed. The size and method of construction of the power house were determined by

the space required for a total of five 23-MVA generating units each of which consists of a Francis spiral turbine and a rigidly coupled three-phase synchronous generator. Arranged between the power house and the inclined wall of the dam are the rooms for the various items of auxiliary equipment (control boards, medium and low-voltage distribution boards for the station-service system, etc.).

In order to reduce the costs, the amount of building work for the power house was kept to a minimum. Thorough investigations were thus necessary to obtain a suitable arrangement of the machines and their accessories, despite the restrictions imposed by this. The requirement that the overall height of the machines be kept as small as possible played a decisive part in the decision to select umbrella generators. These have a shaft and bearing common to the turbine, a feature which makes for minimum height. The thrust bearing and the two guide bearings are arranged below the generator rotor, access for maintenance being provided from the turbine pit.

Another measure which effectively reduced the height of the machines is the separate arrangement of the high-speed exciter sets, thus obviating an exciter

set mounted above the generator and coupled to the generator rotor. The drive motor of the exciter set is provided with power by a three-phase auxiliary shaft-mounted generator operating independently of the mains system. This has a relatively small output of 200 kVA, the number of poles being the same as that of the main generator (corresponding to an operating frequency of 50 c/s). Its design and the method of building it into the generator is such that the overall height of the machine remains the same. The overall height of the machine from the centre of the turbine spiral (elevation 345.643 m) to the top generator cover (elevation 352.450 m) has thus been limited to 6.807 m or 22.331 ft. which is 10 ft. less than that required for a machine of the same size and speed in the conventional type of construction (W 4) with a built-on exciter. The reduced height also improves the appearance of the relatively narrow turbine hall.

The power house has been designed to accommodate five generating units. The fifth generating unit will serve exclusively as a standby unit.

The machine boards, to which has been added a small 400-V distribution board for the unit auxiliaries, have been arranged mirrorwise between two machine foundations so that the machines with the associated control

boards form a closed group against the main service aisle. Located immediately behind the boards, out of sight from the main service aisle, are the turbine governors together with the extensive range of ancillary equipment such as piping to pumps, valves etc. The panels of the machine board are metalclad and provided with special seals to prevent the ingress of dust and insects.

In the physical arrangement the only expedient solution for the accommodation of the current and voltage transformers, the surge arresters on the 11-kV generator connections and the metalclad neutral cubicles was to install them direct by the generator foundation completely separate from the remaining part of the 11-kV switching station. The remaining items of equipment for the power house such as exciters, voltage regulators, de-excitation units and the CO₂ cylinder bank for protecting the generators against fire are arranged along the upstream power house wall.

Generating units

Each generating unit (Fig. 3) consists of a normal vertical-shaft Francis spiral turbine, and a direct-coupled three-phase synchronous generator. The first three units were manufactured by J. M. Voith, Germany (turbine part) and Siemens-Schuckertwerke (generator part).

With a normal net head of 149 ft. and an intake rate of 2,240 cubic ft. of water per second, each turbine delivers to the generator a useful output of 31,500 metric h.p. Under the hydraulic conditions obtaining, the most favourable speed worked out at 187.5 r.p.m.

The entire spiral case has been manufactured in accordance with the latest methods and is of welded rolled-steel construction. The 13-ton chrome-steel Francis

runner is supported by a combined thrust and guide bearing arranged directly on the turbine head cover.

The thrust bearing is designed for a total load of 273 tonnes consisting of the weight of the turbine runner and the generator rotor and the additional hydraulic thrust. The upper guide bearing is located below the generator rotor. For lubrication all bearings incorporate a self-pumping oil system thus obviating the need for separate ancillary pumping equipment. Water cooling coils in the bearing oil tanks dissipate the heat from the oil.

The pressure water is in each case passed to the spiral casing of the turbine through a pipe 164 ft. long which passes through the dam at an angle of 30°. Vertical-lift gates in the intake can be used for emergency shutdown. In view of the short length of the penstock, a shut-off device in front of the turbine was dispensed with. The shutting off of the water during normal operation is carried out by the turbine guide vanes only. Noteworthy features are the two ring-piston servomotors built direct onto the turbine head cover, a new arrangement of the guide-vane apparatus which combines the advantage of a limited number of linkages, and thus a very high degree of reliability, with limited space requirements. Provided in the turbine foundation is a small passage from which the draft tube can be examined at special inspection openings.

The radial bracket for the upper guide bearing serves at the same time as the supporting base for the generator brakes and jacks and for a small permanent-magnet generator which feeds the electric pendulum motor on the speed governor. This generator is fitted with a pinion and is driven from a spur wheel on the turbine shaft.



Fig. 2 The Gandhi Sagar dam during construction (spring 1960)

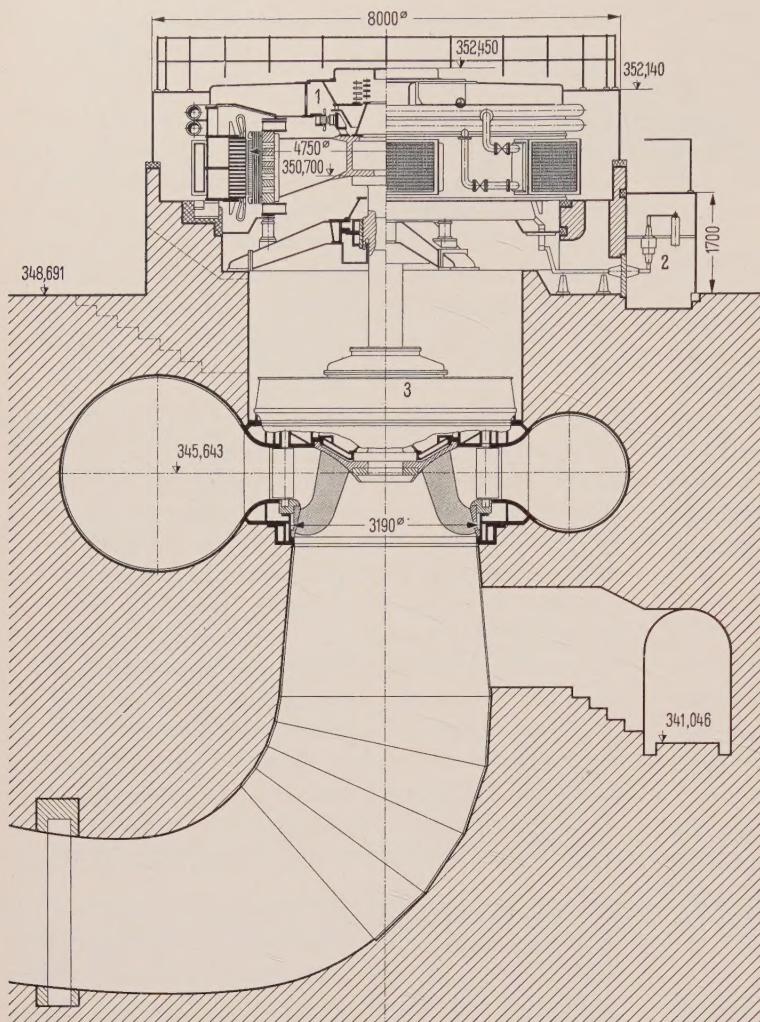


Fig. 3 Section through a 23-MW generating unit (elevations in metres)
 1 200-kVA, 400-V auxiliary shaft-mounted generator
 2 11-kV main generator connections with current transformer and surge arrester sets
 3 Thrust and lower guide bearings

On the basis of the hydraulic values and the conditions obtaining in the system and on the load side, the generators have been designed with the following data:

Rated output	23 MVA
Rated power factor	1.0
Rated voltage	11 kV
Rated speed	187.5 r.p.m.
Runaway speed	402 r.p.m.
Rotor flywheel effect (referred to radius)	5,366,650 lb.-ft ² .

The dimensions of the generators as determined by the output, speed and flywheel effect – the diameter of the bore is 15'-7" – were just sufficient to permit the rotor to be transported and thus manufactured in a single piece. In the case of the stator, sectionalizing into two halves proved sufficient.

Shrunk onto a welded hub with eight arms of I-sections are two solid cast-steel rims. Attached to the rotor rims are the solid cores of the field poles to which in turn are welded the laminated pole shoes which are compressed axially by end plates and bolts. The copper bars forming the damper winding are inserted into the semi-closed slots in the pole shoes. In conformance with standard practice, the damper winding is designed for a negative-sequence current of 20% of the positive-sequence current.

In contrast to the method of coupling usually employed with umbrella type generators – the generator rotor with the machined hub bore is fitted onto the extension of the turbine shaft projecting beyond the upper guide bearing – the generators for Gandhi Sagar were provided with a cast-steel hub having a specially designed lower side which was bolted to a flange on the turbine shaft (see Fig. 3). For the remainder, the method of coupling was the same as that normally employed for coupling two integral shaft flanges.

The stator consists of the welded rolled-steel frame, the core of high-grade dynamo sheets insulated on one side with paper, and the two-layer, transposed-bar wave winding. With tropical insulation according to class B and with corona protection in the slots and at the ends, the winding is of the same design as that usually selected for large generators.

A light-weight bearing bracket – all bearings are on the turbine side – carries the upper generator cover and the stator of the auxiliary shaft-mounted generator built into the housing of the main generator. The auxiliary generator which is a standard three-phase synchronous generator has an output of 200 kVA and a rated voltage of 380 V and serves to supply power to the entire excitation system of the unit.

On the principle of load-sensitive compounding, the voltage of the auxiliary generator is kept constant with an accuracy of $\pm 1\%$. The rotor is secured directly to the hub of the main generator and since it has the same number of poles as the latter produces a frequency of 50 c/s.

Arranged above the shaft-mounted generator are four slip-rings for supplying the excitation current to the main and auxiliary generators. Screened louvres in the

upper cover permit direct ventilation of the slip-rings from the machine hall. In addition to this, they provide easy access to the slip-rings for the purpose of maintenance.

The heat losses of the generator are dissipated through a closed-circuit cooling system. Six water-cooled elements on the stator rim reduce the temperature of the outlet air from a maximum of 60 °C (on full-load operation) to at least 40 °C. The cold air is then drawn from the top and bottom into the generator by the two fan rings mounted on the generator rotor.

The unfavourable conditions for the cooling of the air made necessary a relatively large cooling unit. In the hottest season of the year, the cooling water taken from the penstock attains temperatures of up to 35 °C and with this the outlet air must be cooled down to a temperature of 40 °C. Another difficulty which arose in the design of the cooler was the requirement that at rated operation the entire heat produced must be dissipated by five coolers. Since the temperature in the machine hall may rise up to 50 °C and thus be 10 °C above the cold air temperature required for the generator, it was also necessary to make provision for a reserve cooling capacity.

These conditions not only made necessary relatively large cooling elements but also a water supply of 8,300 cubic ft. per hour which for a generator of this size is unusually high.

All important cooling circuits of the generator and turbine equipment are supervised by flow monitors and pressure gauges locally and from the machine boards.

In order to prevent excessive coasting times when the units are shut down, the generators are provided with hydraulic brakes. These are supplied with oil at a pressure of 355 psig from the air/oil vessel of the turbine governor.

The pressure of the oil in the feed pipe to the brakes is reduced by a valve to a value of 114 psig suitable for the braking device. The oil feed is controlled by an electro-magnetically operated three-way valve which can be remote controlled from the machine board by means of a pushbutton or controlled automatically through the medium of a speed-sensitive relay. On normal shut-down of the generating unit, i.e., when the turbine water is shut off and the brakes are applied at 50% of rated speed, the brakes reduce the coasting time to approximately four minutes. In an emergency the brakes can, of course, be applied at rated speed.

When inspections or repairs are being carried out on the thrust bearing, the brake jacks can be used to lift the entire rotating part of the generating unit. For this, the feed pipe to the brakes is switched over to a special hand pump with which the required pressure of 2,300 to 4,300 psig can be produced. In the raised

position, the brake jacks can be locked by check nuts and the pressure released. Auxiliary contacts on the brake jacks make it possible to transmit a signal to the machine board to indicate that the brakes are in the operating position. In addition to this, the brake pressure in the feed pipe is indicated by a pressure gauge on the machine board.

On account of the high degree of humidity, it is of particular importance that the formation of moisture condensation in the interior of the machine be prevented when it is shut down. Each generating unit is therefore provided with six tubular heaters with a total rating of 4.8 kW, these being arranged under the stator winding.

The high ambient temperatures of up to 50 °C in the shade involved particularly high expenditure for thermal supervisory devices. The temperatures of the stator winding are supervised by 12 resistance thermometers uniformly distributed round the periphery of the stator. Some of these are connected to indicating instruments and some to temperature recorders in the machine hall. The stator winding of the shaft-mounted auxiliary generator is likewise equipped with three resistance thermometers. In addition to this, a total of eight resistance thermometers is installed for the supervision of the generator cooling air and the incoming and outgoing cooling water, the indicating instruments for these being arranged on the machine board. Built into the openings for the hot air on the stator rim are thermostats some of which are used for indication only and some for the automatic operation of the CO₂-fire extinguishing system in the event of the generator hot air temperature exceeding the permissible values.

A noteworthy feature is the thermal supervision of the generator rotor by means of a special quotient measuring device. The quotient obtained from the values of the voltage and current of the magnet-wheel circuit, measured on the slip-rings by special brushes, provides a criterion for the total resistance of the rotor winding and thus (with suitable calibration of the measuring instrument) of the mean temperature of the magnet-wheel winding.

Of decisive importance to the operating reliability and to the prevention of damage to a generating unit is the supervision of the bearing temperatures. For this reason each of the three bearings is provided with a resistance thermometer and the detector of a mercury distant-reading dial thermometer which are likewise coupled to temperature indicators on the machine board.

In the event of the temperatures of the bearings assuming abnormal or dangerously high values, a two-stage contact mechanism in the distant-reading thermometers initiates an alarm and a tripping signal for the shut-down of the generating unit.

11-kV main generator connections and neutral cubicle equipment

The power produced in the generator is transmitted to the unit transformers in the 132-kV outdoor switching station via three circuits of parallel connected single-core paper-insulated lead-sheathed cables. As already mentioned, the 11-kV cable sealing ends and all the associated current and voltage transformers, surge arresters and current transformers in the generator neutral leads have been installed in a separate group of metalclad cubicles which are arranged round the upstream side of the generator foundation in the shape of a partial polygon. Each cubicle is accessible from the machine hall through a sheet-steel door at the front. Here, too, special seals were provided to prevent the ingress of vermin and reptiles from the cable ducts.

With a height of 5'-7" above the machine hall floor, the cubicles were low enough to permit their top covers to be used as the intermediate platform for the stairway. From this platform, a door leads through the air-circuit jacket to the annular cold-air chamber of the generator.

Voltage regulating system

For the maintenance of constant voltage, the generator has been provided with a modern magnetic-amplifier voltage regulator of the two-stage type. The regulating accuracy is $\pm 0.5\%$, i.e., on all load fluctuations between full load and no load the voltage is regulated to the preset reference value with this degree of accuracy within a period of 1.5 seconds. The response time of the regulator when fully opened (shock excitation) is 0.1 to 0.2 seconds.

In order to give the voltage regulator the required static regulating characteristic, additional intermediate transformers and variable resistors are incorporated in the

measuring circuit. Through the medium of these the reactive components of two phases are impressed onto the measuring circuit. The droop elements permit the natural droop characteristic produced by the unit transformers to be varied by values of up to $\pm 10\%$.

Special measures, particularly non-inductive resistors in the exciter field circuit, and generous dimensioning of the exciter and voltage regulator made it possible to obtain for the entire excitation system (voltage regulator and exciter) a remarkably low response time of 1.4 per second.

Although the fact that the magnetic-amplifier voltage regulator has no movable parts which are subject to wear makes it extremely reliable, it was supplemented by an independent hand regulating device.

De-excitation system

The de-excitation system operates on the principle of the field-proven oscillation de-excitation which is of the improved type with additional current and voltage control of the de-excitation operation. Despite the high inductance of the rotor (damper cage designed for a negative-sequence current of 20%) this arrangement makes possible a de-excitation time of 2.5 to 3 seconds, even at no-load de-excitation.

Commissioning

Following an erection period of about 2 years, the Siemens-Voith generating units were put into trial operation at the end of August 1960 and in September switched onto the 132-kV overhead line to Ujjain which was completed at approximately the same time. In October, the third machine was commissioned and, in November 1960, the official inauguration of the Gandhi Sagar power station took place in the presence of Prime Minister Pandit Nehru and other representatives of the Indian Government.

Illuminated Buttons for Indication and Switching

BY JOHANN-FRIEDRICH FRANZEN AND HEINZ VOGEL

Manual signaling and switching devices present points of contact between man and technology. They indicate occurrences, relay instructions, announce readiness for operation and the completion of operations. The requirements imposed upon such devices in communications engineering are increasing with the advance of automation. This is particularly true with respect to switching reliability, easy handling, clear identifiability of indications and switching positions, and the functional clarity

of control panels in which they are used. These requirements have resulted in the development of new types of illuminated buttons.

Trend of development

It was common practice hitherto to use respectively different devices for the on/off switching of circuits and for indication purposes. Among the devices used there were toggleswitches, pushbuttons, rotary buttons, indication

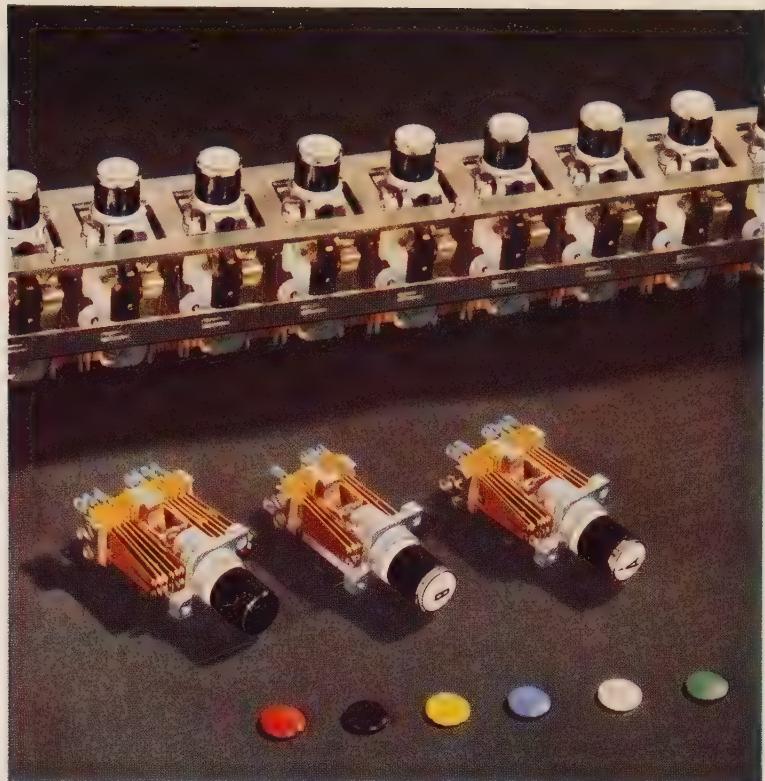


Fig. 1 Some of our new illuminated buttons. Seen in the background is a strip of illuminated buttons arranged for reciprocal release. Their colored caps are seen in the foreground

lamps and visual indicators, mounted either singly or assembled into strips. There were accordingly many different types of control panels for switchboards, control consoles, test sets, etc. A variety of illuminated buttons of similar appearance (Fig. 1) unite the functions of these devices in an optimum manner for any given problem.

Development began in 1953 with a design that is today known as the "large illuminated button" (Fig. 2). This was a non-locking, i.e. self-restoring, pushbutton embodying an indication lamp, and was used primarily in telephone switchboards and communications control panels. Owing to its large mounting height, it could not be used in small equipment such as desk telephones (executive and secretary telephones, PBX telephones, etc.). This mounting height was necessary on account of the dimensions of the then conventional indication lamp with base.

Thus the desired miniaturization had to begin with the indication lamp. A new type was adopted that had already proven its worth in the automobile industry (Fig. 3). It is considerably shorter than its predecessor and its bayonet-type base insures a secure mount and thus high contact reliability even under exposure to considerable vibration and impact. It appeared inadvisable to choose a smaller lamp because the operating reliability of an incandescent lamp depends, in part, for physical reasons, on the volume of the glass bulb.

Several improvements were necessary before the lamp could be used in communications equipment: closer tolerances had to be specified for its dimensions and short-circuit protection had to be improved by enlarging the insulating block of its base. By a double-suspension arrangement of the filament it was found possible not only to increase the light yield in the axial direction but also to improve considerably the stability of the filament and thus the mechanical resistance of the lamp. To secure the required life of 1000 hours of operation, test voltages considerably above the respective rated voltage were chosen. The principal data are tabulated below:

Rated voltage in volts	6	12	24	48	60
Rated current in amperes	0.10	0.05	0.025	0.025	0.025
Voltage for life test in volts	7	14	28	56	66
Average minimum burning period at 40°C ambient temperature in hrs	1000	1000	1000	1000	1000

With the aid of the small communications lamp with base so arrived at, a new line of illuminated buttons of very low mounting height was developed whose versatility meets all practical requirements.

These lamps are also readily replaceable by tactile indicators (Fig. 3) for sightless personnel. A tactile pin

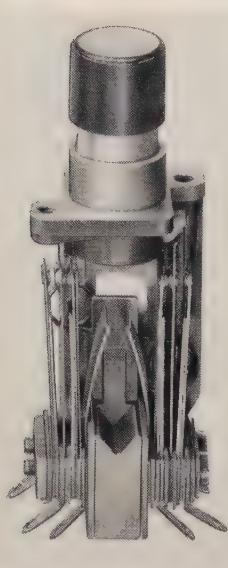


Fig. 2 The "large illuminated button", predecessor of the new illuminated buttons, in its natural size

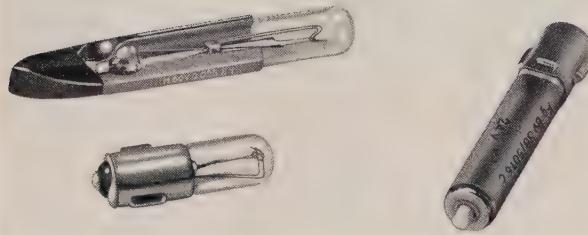


Fig. 3 The hitherto conventional small communications lamp with base (top left) and the new small communications lamp with bayonet-type base, shown in their natural size. The tactile indicator on the right is provided for sightless attendants in place of the new small lamp

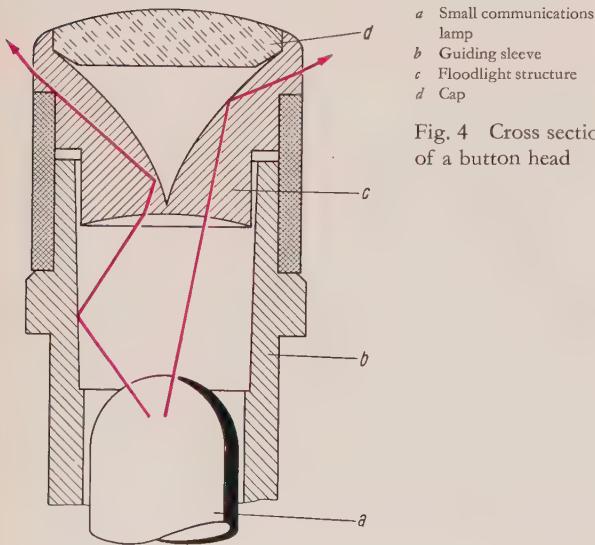


Fig. 4 Cross section of a button head

here projects through an opening in the head of the button. With the aid of these tactile indicators it is possible, as hitherto, to adapt a PABX attendant telephone for use by a sightless attendant.

New line of illuminated buttons

Like their predecessors, the new small illuminated buttons have two contact pileups with a total of up to 24 contact springs (Fig. 1). The springs are actuated by the guiding sleeve when the head of the button is pressed or turned. The indication lamp in the cavity of the sleeve does not move during this operation.

Special measures were taken to insure that the light of the indication lamp is clearly visible under all circumstances and even in sunlight. With the translucent colored lenses used previously, the dark colors such as green and blue absorb much light. The head of the new illuminated buttons, however, contains a floodlight structure (Fig. 4) which deflects the light of the lamp from below so that it emerges focused through the top rim of the button. This illuminated rim of the otherwise black button stands out particularly clearly, especially when looked down upon from the side. At the top the floodlight structure is provided with a non-translucent cap, which is available in various colors with the identity of the button engraved upon it (Fig. 1). It shields the floodlight structure from other light; as its diameter is smaller than that of the head of the button, the illuminated rim is also clearly identifiable from above. The white plastic guiding sleeve increases the illumination by acting as a reflector.

With respect to their switching functions, the illuminated buttons can be classified in three groups, each of which contains a number of variations:

1. Non-locking illuminated buttons
 - Illuminated pushbuttons
 - Illuminated rotary buttons
 - Illuminated rotary pushbuttons
2. Locking type illuminated buttons
 - with self-release when pressed anew
 - with reciprocal release when another button is pressed with automatic release from a central point (e.g. when telephone handset is replaced)
3. Illuminated magnetic buttons
 - with electrical release through interruption of holding circuit.

In the first group (Fig. 5, left) the various versions differ only with respect to the guiding sleeve for the button. The bodies of the buttons are basically identical, as are also their contact pileups except for their number of contacts. In the case of illuminated rotary pushbuttons, one contact pileup is acted upon when the button is pressed, while the other is acted upon when the button

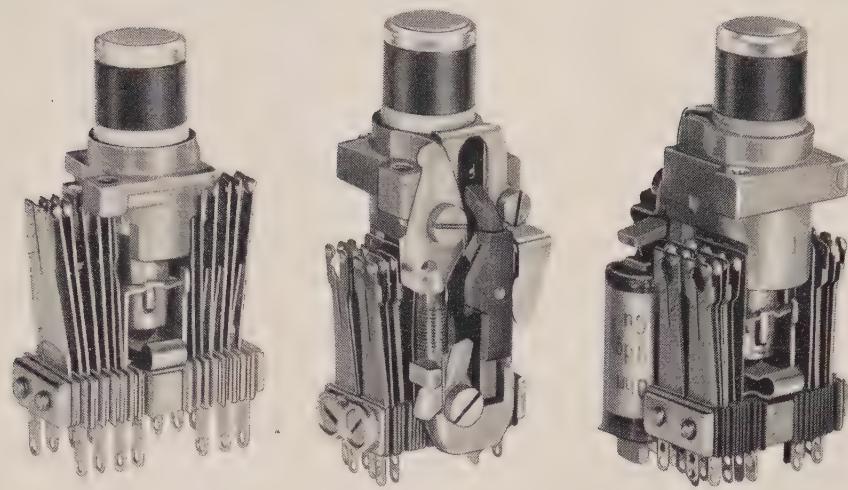


Fig. 5 Non-locking illuminated button, locking type illuminated button (with self-release) and illuminated magnetic button, all shown in their natural size

is turned by 90 deg. Both functions are independent of each other.

In the second group (Fig. 5, center) the method of release depends on the design of the locking lever; here, too, the bodies and contact pileups of the buttons are identical. Buttons designed for external release are usually assembled in a strip. Their locking levers are in that case interconnected by a rod. Suitable lever arrangements are provided for linking several button strips and, if necessary, for connecting up an external tripping device.

Illuminated magnetic buttons (Fig. 5, right) form a group by themselves, but their heads are completely identical with those of the other groups. Thus illuminated buttons in all their variations have a similar appearance when mounted.

Mounting and application

Having identical mounting dimensions, illuminated buttons can be used on a large scale. They mount in metal shelves or plates with the aid of two screws; the openings are designed to permit observation of the contacts from above. The round mounting holes for the buttons in the telephone housing are each fitted with a ring. This secures a dusttight seal and its lateral clearance bridges all mounting tolerances, thus insuring the easy operation of the button head under all circumstances. Fig. 6 shows as an example the button array of a telephone.

To increase the uniformity of control panels, illuminated buttons are also used

in cases where only an indication lamp without any switching function or only a pushbutton or rotary button without a lamp is required. In Fig. 7 these non-illuminated buttons are shown on the left, while illuminated buttons proper appear on the right.

The versatility evident from Fig. 7 shows the new illuminated buttons to be suitable universal components for all types of attendant telephones.

The combination of up to three functions in a single device offers new interesting possibilities to the circuit



Fig. 6 Button array of PBX telephone with two outside trunks; the line buttons at the top are for five extensions

 Indication lamp without switching function	
Non-illuminated buttons	Illuminated buttons
	Illuminated pushbutton, non-locking
	Illuminated rotary button
	Illuminated rotary pushbutton
	Illuminated pushbutton, locking type
	Illuminated magnetic button

Fig. 7 Survey of principal functions of illuminated button. The symbols are used, for example, in face plans for button arrays; the various types of release in the case of locking type buttons are not indicated

designer for the development of new circuits that reduce to a minimum the possibility of buttons being operated wrongly. Indication lamps can be circuited, for instance, to burn steadily, flash or blink as a signal to the attendant to actuate the respective button, or as a return indication that a certain switching operation has been completed.

Maintenance requirements are fully met. All important components are easily accessible. The solder tags of all buttons lie in the same plane. Defective lamps can be taken out without difficulty with a lamp extractor after removing the button head.

The small overall size of the new illuminated buttons and, in particular, their low mounting height, gives industrial designers a free hand in the styling of attendant telephones, while at the same time making the handling of such telephones easier.

Experience gained with Aluminium-sheathed Power Cables

BY FRIEDRICH OTTEN AND LOTHAR HEINHOLD

Siemens-Schuckertwerke have been manufacturing aluminium-sheathed cables since 1941. The development work and the present-day methods of manufacture have been described in detail in a previous article [1]. Owing to the fact that all data, together with the manufacturing plant, were lost as a result of the war, it is not possible to give a report on the aluminium-sheathed cables which were installed for power and communication applications up to 1945.

Fields of application

Of the various fields of application for cables with aluminium sheaths the one which has gained most in importance is the construction of urban networks [2, 3]. Here the use of the aluminium sheaths as the neutral conductor effects appreciable savings so that in many cases the first and operating costs are low enough to enable them to compete with overhead line systems [4, 5]. This point is of special significance where existing overhead lines have to be modified or reconstructed owing to increases in load demand.

In some cases the cross-section of the aluminium cable sheath is appreciably larger than the corresponding cross-section of the main conductor and, converted to the conductance value of copper, larger than the equivalent neutral cross-section of a $3\frac{1}{2}$ -core cable

(Fig. 1). In addition to this, the inductive reactance of the loop main conductor to aluminium sheath is smaller than the loop main conductor to neutral conductor in the case of a $3\frac{1}{2}$ or 4-core paper-insulated lead-sheathed cable (Fig. 2). This gives rise to higher fault currents on short circuit, and conformance with the requirements concerning protective connection to the neutral is simplified.

In accordance with the specifications of the Association of German Electrical Engineers VDE 0286, belted cables with aluminium sheaths can carry the same load as corresponding cables with a lead sheath. In the case of an unbalanced load, the temperature rise of the aluminium-sheathed cable is lower, as is shown by the following calculation. To simplify the calculation it has been assumed that the current (I) flowing in the three phases is equal in magnitude but not displaced by 120° , as is the case with symmetrical three-phase operation. The current flowing through the neutral conductor is I_0 whose magnitude is determined by the vectorial sum of the three phase currents.

If the resistance of the main conductor is R , that of the neutral conductor R_0 , and that of the aluminium sheath R_{M0} , the steady-state temperature rise on the conductor is

$$\vartheta_A = 3I^2 R \sum S + I_0^2 R_{M0} (S_a + S_e)$$

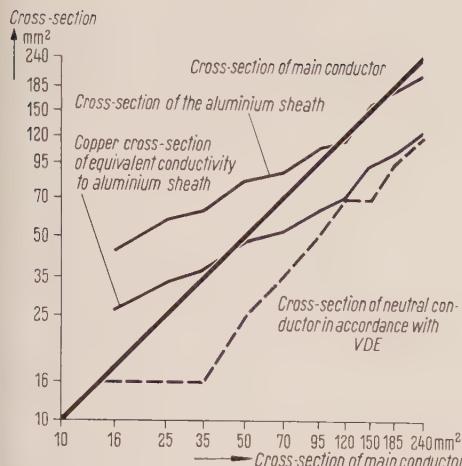


Fig. 1 Cross-section of the aluminium sheath of 1-kV three-core cables ($1 \text{ mm}^2 = 0.00155 \text{ sq.in.}$)

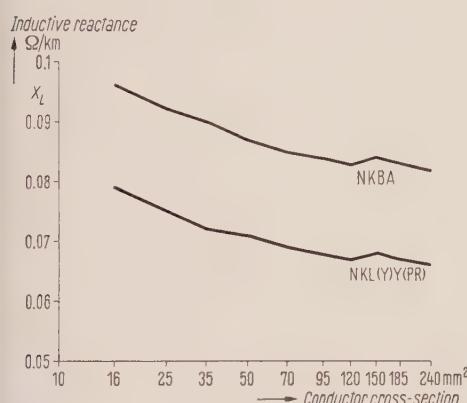


Fig. 2 Inductive reactance X_L of the loop main conductor to aluminium sheath and main conductor to neutral conductor of three-core aluminium-sheathed cables NKL(Y)Y and three-core and neutral paper-insulated lead-sheathed cables NKBA respectively

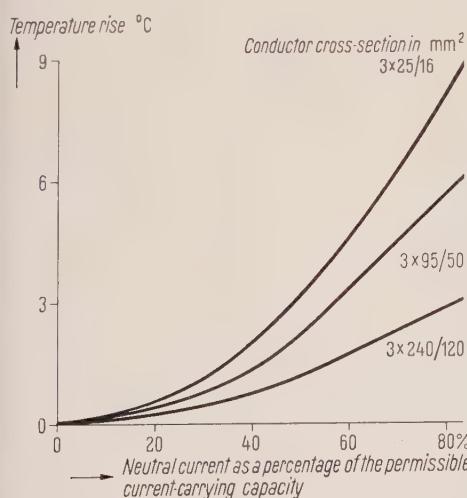


Fig. 3 Temperature increase of 3½-core lead-sheathed cables, type NKBA 1 kV, compared with three-core aluminium-sheathed cables, type NKL(Y)Y 1 kV, carrying unbalanced load (the aluminium sheath serves as the neutral conductor)

for three-core aluminium-sheathed cables employing the sheath as the neutral and

$$\vartheta_B = 3I^2 R \Sigma S + I_0^2 R_0 \Sigma S$$

for three-core lead-sheathed cables with a neutral conductor.

In the equation S_a is the thermal resistance of the protective coverings of the cables, S_e the thermal resistance of the soil and ΣS the sum of all the resistances, including the thermal resistance of the insulation. There is no appreciable difference between either type of cable as far as the thermal resistance is concerned (where the load is symmetrical, the current-carrying capacity is the same). The difference in the temperature rise on unbalanced loads is expressed by the equation:

$$\Delta\vartheta = \vartheta_B - \vartheta_A = I_0^2 [R_0 \Sigma S - R_{M0}(S_a + S_e)]$$

Fig. 1 shows that in the case of cables with copper conductors the resistance of the neutral conductor, and in the case of cables with aluminium conductors the resistance of the main conductors, is always greater than that of the aluminium sheath.

In addition to this, ΣS (total thermal resistance of paper-insulated lead-sheathed cables) is greater than $S_a + S_e$ (sum of the thermal resistances of the cable outer servings and of the soil in the case of aluminium-sheathed cables).

The difference in the conductor temperature of the two types of cable is shown in Fig. 3.

Aluminium-sheathed cables have given excellent service in locations where heavy vibrations make it inadvisable to use lead-sheathed cables (e.g., on large machines such as excavators and spoil-disposal machines in open-cast lignite mines).

Single-core aluminium-sheathed cables can also be used to advantage as railway feeder cables, in which case the aluminium sheath acts as the return conductor. Where control cables are run parallel to high-voltage cables or overhead lines, the aluminium sheath reduces the voltage induced in the cores on the development of a short circuit in the high-voltage system [6].

Experience gained in the installation of cables

As early as in the initial trials it was established that a smooth hot-extruded sheath of high-grade aluminium, while providing a high degree of strength, remains adequately flexible. The permissible bending radii of these cables are only slightly smaller than those for lead-sheathed cables, a condition which in the case of cables buried in the ground is of no importance (Fig. 4). Thus for the usual range of diameters there is no need for subsequent corrugation of the aluminium sheath in the bend.

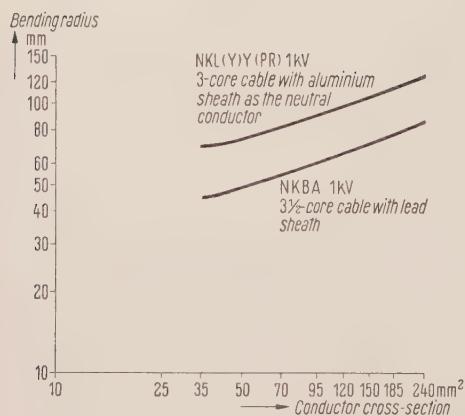


Fig. 4 Comparison of the permissible bending radii of the various types of cables (1 mm = 0.03937 in.)

An advantage in installation is that the construction of aluminium-sheathed cables differs only slightly from that of lead-sheathed cables. It is therefore possible to use the same fittings. No special tools are required for removing the smooth, soft aluminium sheath. As with lead sheaths, a sturdy knife suffices. Only for soldering was it necessary to develop a special method which is simple and reliable.

In actual practice the method which has found general acceptance for the tinning of the aluminium sheath is that of soft-solder wiping which can be carried out quickly and simply, in contrast to the tinning of the many individual strands of an aluminium conductor. The high thermal conductivity of the aluminium sheath obviates the danger of the cable core assembly being damaged due to overheating of the metal sheath during

soldering. Also the high melting point of aluminium precludes the possibility of the sheath melting due to a prolonged soldering period. Installation trials with untrained personnel and even personnel unfamiliar with the trade showed that when soldering on the copper bonding conductor required for the connection of the aluminium sheaths in junction boxes, improperly made joints are capable of withstanding extremely high short-circuit stresses. Tests were carried out to determine the characteristics of the soldered joints of bonding conductors. When the soldered joints were loaded with a mean short-circuit current of 4 kA for a period of 23 seconds, a copper conductor with a cross-section of 95 mm^2 (0.147 sq.in.) began to glow without the soldered joints softening (Fig. 5). At very high short-circuit currents the copper conductor has even melted without the soldered joints running.

The results of these tests are confirmed by practical experience. By the beginning of January 1960 the Berliner Kraft- und Licht (BEWAG) - AG, a power and lighting company, had installed on aluminium-sheathed cables approximately 30,000 junction and house-service boxes and approximately 10,000 sealing ends [7]. As yet, no faults have been reported on any soldered joints. This has also been the case with large urban networks of the Stadtwerke in Bremen [8], the Elektrizitäts-Aktiengesellschaft Mitteldeutschland (EAM) in Kassel and the Hamburgische Elektrizitäts-Werke AG (Hew). Aluminium-sheathed cables have also been installed on a wide scale in many urban networks under a great variety of conditions, without there having been any reports of trouble with soldered joints. All this should provide ample evidence of the reliability of the simple installation method.

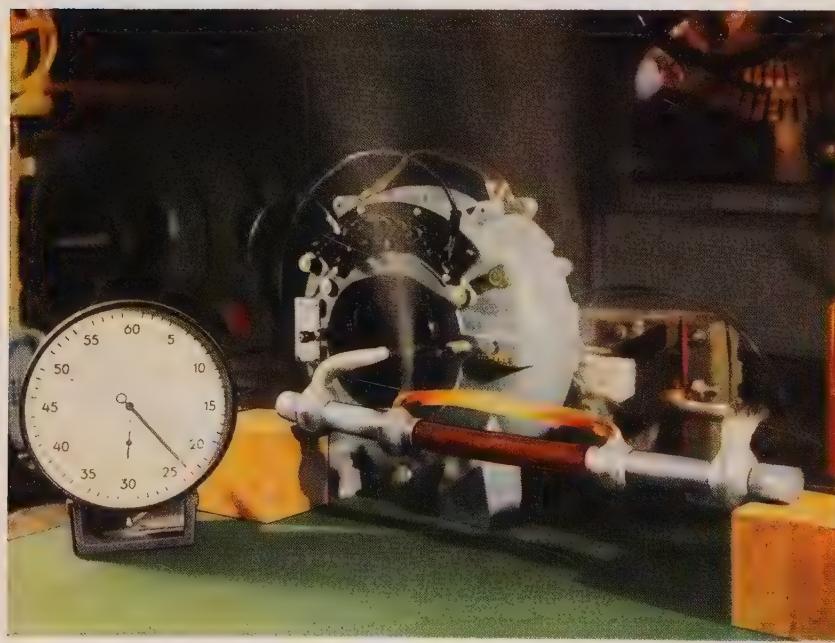


Fig. 5 Copper conductor soldered to the aluminium sheath after being loaded with a mean short-circuit current of 4 kA for 23 seconds

With a more recent method for the connection of house-service boxes, the aluminium sheath can be so separated and opened by making a curved incision that the sheath, i.e., the neutral conductor, remains intact while the cable cores are easily accessible for the fitting of claw-type terminals. This method will probably find more widespread application as soon as simple, handy tools are available for separating the sheath.

Corrosion protection

Since the introduction of aluminium-sheathed cables, the interest taken in the various types of corrosion protection has shown a marked increase. This can be attributed to the fact that the life of these cables is influenced directly by the corrosion protection.

Tests carried out over a long period of time have shown that servings of textiles embedded in compound do not in the long run provide the aluminium sheath with adequate protection against corrosion. When reinforced with a layer of rubber tape, however, these servings are resistant to both chemical and electrolytic action. Many years of experience have proved that this also holds good for lead-sheathed cables buried in corrosive ground in which they are exposed to electrolytic action. Inadequate protection can relatively quickly lead to breakdowns due to corrosion of the sheath. Cable manufacturers in other countries who at first only provided the cables with normal protective servings of textiles and compound – similar to those used for lead sheaths – confirm this [9, 10].

In Germany on the other hand a new corrosion protection was selected right at the very beginning so that the number of failures caused by corrosion of the smooth aluminium sheath is very limited indeed. In most cases the faults have been due to unavoidable defects in manufacture or to subsequent heavy damage of the protective serving. Experience has also shown that corrosion protection consisting of a simple thermoplastic sheath not bonded to the aluminium sheath (single-layer protection) is somewhat susceptible to mechanical damage [11]. This fact prompted an early changeover to multi-layer corrosion protection (Fig. 6) or at least to bonding of the thermoplastic sheath to the aluminium sheath with an adequately strong layer of compound.

Practical experience and the results of numerous tests have shown that corrosion cannot cause fracture of the aluminium sheath serving as the neutral conductor, even where the conditions are unfavourable. In the event of damage which exposes the bare aluminium sheath, this corrodes only at the point affected. It is not possible for the corrosion to spread over the entire extent of the aluminium sheath covered by an intermediate layer of compound since moisture would penetrate into the core assembly and cause an electrical breakdown before this

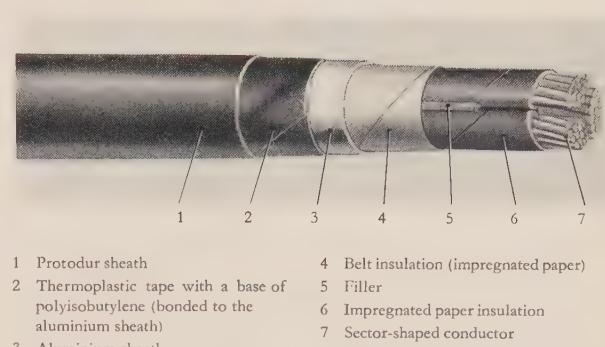


Fig. 6 Aluminium-sheathed cable with multi-layer corrosion protection, type NKL(Y)Y(PR)

could happen. Also in the case of cables with which moisture was able to spread over the entire aluminium sheath following damage to the thermoplastic sheath, the damage caused by corrosion was only punctiform. Thus in the few cases in which a defective or damaged corrosion protection gives rise to a cable fault there is no danger of fatal accidents due to breakage of the neutral conductor.

Conductive corrosion protection

A lead-sheathed cable with the usual corrosion protection of textiles embedded in compound improves the earthing of the system. In the case of aluminium-sheathed cables, however, it is generally necessary to dispense with this additional earthing by the metallic sheath on account of the insulating corrosion protection. Despite this, the large number of cast-iron house-service boxes in an urban network will provide relatively good earthing.

In order to meet the requirements for a noninsulating corrosion protection, Siemens-Schuckertwerke developed a conductive corrosion protection with a base of polyisobutylene. This protection, which is known under the name of SIMANDUR*, has to date given very good service.

SIMANDUR should not, however, be employed where there is any likelihood of d.c. stray currents flowing in the ground. It is also undesirable to have too high a potential between the aluminium sheath and earth since this introduces the danger of the SIMANDUR protection being destroyed by overheating, e.g., due to inadvertent connection of the phase voltage to the sheath or to the cable passing through the resistance area of high-voltage earthing electrodes.

Inclusion in the Specifications of the Association of German Electrical Engineers (VDE)

In view of the success achieved with aluminium-sheathed cables, they were included by the VDE in 1956 in the "Specifications for metal-sheathed power cables for ex-

* Trade-mark

perimental purposes" VDE 0286/10.56. Since cables with aluminium sheaths have, in the meantime, proved extremely reliable under a very wide range of operating conditions, it can be expected that they will shortly be included in a final specification.

Proof of the reliability of an entire network constructed of aluminium-sheathed cables with the sheath serving as the neutral conductor has been provided in particular by several large electricity supply undertakings. Since 1953 the BEWAG alone has installed in its low-voltage network about 810 miles of three-core aluminium-sheathed cable [7]. All this prompted the VDE Commission 0100 to test the reliability of aluminium sheaths as the neutral conductor. The result was that aluminium sheaths were approved for use as the neutral conductor in VDE 0100/11.58. § 10 N 13.

This survey shows that aluminium-sheathed cables have by reason of the many technical and economic advantages which they afford found a wide field of application. The ever increasing demand, particularly in the construction of urban network systems, reflects the progress being made. This success is due entirely to the comprehensive

preliminary work which has been carried out and to the care taken in manufacture, both of which contribute to the high degree of reliability attained with and expected of the aluminium sheath.

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Aluminum-Sheathed Communications Cables

BY RUDOLF ZÖCKLER† AND NORBERT ODEMAR

Progress in cable design

Owing to a sharply rising demand accentuated by previous shortages, the communications networks of the German PTT, railroads, civil services, and private business organizations underwent considerable expansion from 1945 onwards. Despite high procurement costs, cable is still more widely used than radio relay systems, open-wire lines, and all other transmission media. Its great operating reliability, immunity from interference, and flexibility with respect to the choice of frequencies also guarantee its leading position for a long time to come.

As a result of the numerous innovations with respect to the internal and external makeup of communications cables that have been introduced over the years, a great many types of cable are today available in addition to the traditional paper-insulated lead-sheathed variety. From the aspects of operation and economy there is therefore satisfactory adaptability to a wide range of applications. It may be recalled that the use of plastics for insulation purposes secured increased reliability and opened the way to very large channel capacities. As far as sheathing is

concerned, the use of plastics, steel and aluminum has brought heavy competition to lead. The following deliberations are concerned with aluminum sheathing and its applications.

Lead owes its dominant position among cable sheathing materials to its good plasticity and resistance to corrosion. Its drawbacks are its great weight, sensitivity to mechanical vibration, and poor electrical conductivity. Aluminum is free of these three drawbacks. In its ductility it is relatively close to lead, although like all lightweight base metals it is inferior to lead with respect to resistance to corrosion. It can, however, easily be protected from corrosion, modern nonaging plastic materials being particularly suitable for this purpose [1].

The advantages offered by aluminum have resulted in this metal becoming an important sheathing material for certain applications. This has especially been the case since a method was devised with which aluminum sheathing can be made by hot extrusion in the same way as with lead [2]. Even though the low weight and mechanical strength of aluminum are welcome advantages, the cardinal reason for the installation of many hundreds of

miles of aluminum-sheathed communications cable is, of course, that its conductivity is about 7.5 times better than that of lead. Wherever cables have to be shielded from external interference, this can be accomplished for the least cost by taking advantage of the good conductivity of aluminum. We shall therefore treat of several types of induced interference which have been successfully overcome through the use of aluminum-sheathed cables.

Protection against powerline interference

Whereas buried cable and aerial cable with grounded shielding are not influenced by the electric field, great attention must often be devoted to the magnetic field. If powerlines run continuously or at intervals in close proximity to and parallel with a communications cable, and if they are operated continuously or at short intervals via ground, their ground currents induce considerable electromotive forces in communications cables. These forces are liable to disturb communications transmission or damage the cable and parts of the system. Persons operating the communications system will also be endangered [3].

The dangerous voltage here to be expected can readily be calculated in advance, the magnetic coupling of two ground circuits being comparable with that of a coreless transformer. The ground circuit of the powerline corresponds to the primary of the transformer and the ground circuits of the communications lines to its secondary. As communications lines are insulated with respect to ground, the secondary of the transformer, as it were, is operated in an open-circuit condition. The greater the spacing between the two lines, the greater is the magnetic leakage of the equivalent transformer. Expressed by the mutual inductance, the magnetic coupling increases with the length that the two lines run in parallel and with their proximity to each other. If the current in the primary now rises, the emf in the secondary may become so large that a flashover occurs at the ends of the windings. In concrete terms, this means the destruction of the insulation of the communications cable.

For a given primary current the induced emf can be kept low by spacing the lines far apart in order to reduce the mutual inductance. In many cases, however, wider spacing is not possible on account of the terrain or because, say, the lines run alongside a railroad track. The emf must here be reduced by other means. It is known that the secondary voltage of a transformer with a given primary current will be low if the transformer is given a third, shunted winding. This shunt is established in practice by running a grounded compensation conductor parallel with the influenced line. The optimum effect is obtained if this conductor encompasses the communications line in the form of a sheath; i.e. if it is closely linked with the secondary winding.

The voltage-reducing effect of the sheath is expressed by the reduction factor r_k [4], where

$$r_k = \frac{R_M}{R_M + j\omega L_A}$$

R_M denotes the resistance of the sheath in correspondence with the resistance of the shunted winding of the transformer; ωL_A denotes the self-inductance of the shunt. It is possible to reduce r_k further by using steel tape armoring to increase the mutual inductance between the sheath and the group of conductors, and hence also the self-inductance of the ground circuit of the sheath and the self-inductance L_A .

In difficult cases of interference it was earlier the practice to reduce the excessive resistance R_M of the lead sheath by placing a layer of copper wires under it. The use of aluminum sheathing, whose conductivity is about 7.5 times superior to that of lead, thus also saves copper.

The worst type of interference occurs with powerlines whose operating circuit is closed via ground as in the case of electrified railroads. A railroad cable running along in parallel with the permanent way is thus exposed to strong magnetic coupling. The shielding efficiency of lead-sheathed cable is not usually sufficient in the case of high traction currents – especially in the presence of shorts between trolley wire and rail – to reduce the induced voltages to a level tolerable for the cable plant. Aluminum-sheathed cable here finds a wide range of application.

Fig. 1 shows a busy railroad line in the Rhineland for which the Siemens organization in recent years supplied the same type of aluminum-sheathed railroad cable as earlier for the München-Ingolstadt route. Aluminum-

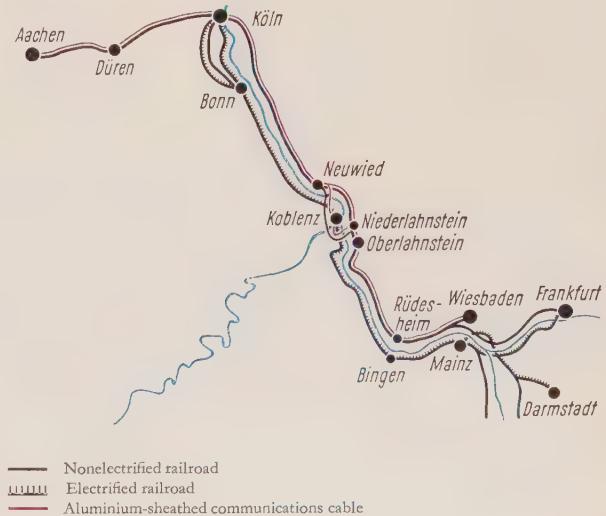


Fig. 1 Aluminum-sheathed railroad communications cable in Rhineland

sheathed railroad communications cables were also supplied to countries outside Germany, e.g.

India approx. 300 km cable for running parallel with a 50-cps railroad line

South Africa approx. 160 km cable for running parallel with a d-c railroad line with parallel 88-kv feed line.

In the case of the Indian project another firm had advised using a lead-sheathed cable and sectionalizing the lines with transformers, but the customer chose the aluminum-sheathed cable as more favorable with respect to both operation and price.

Whereas only the danger to the cable demands consideration in the case of railroad communications cables, voltages induced in PTT systems by traction current sometimes disturb signal transmission if ground-return circuits are used. Local junction cable in the Frankfort postal area, for instance, came to be influenced by 16^{2/3}-cps traction current. This resulted in the selection of wrong numbers and in the undesired triggering of devices due to the use of ground-return circuits for signaling. With the system mentioned the emf induced in the ground circuit must not exceed 10 v. This means that, for low field intensities, the reduction factor for 16^{2/3}cps must not exceed about 0.1. This was accomplished by using an aluminum sheath of larger cross section than that indicated in Fig. 2, and heavier steel tape armoring. The problem was in this way solved at lesser cost than having to change the systems. Fig. 2 shows the reduction factor curves for aluminum-sheathed cable and lead-sheathed cable at 16^{2/3} cps and 50 cps [5].

Although no dangerous overvoltages are to be feared where communications cables are run parallel with d-c railroad lines, communications cable that comes close to the d-c line must be protected against vagabond currents; communications transmission is also liable to be disturbed because d-c networks fed by a current converter have a considerable harmonic content that may disturb telephone circuits. Owing to its high conductivity, an aluminum sheath shields communications cable against v-f disturbance of this type far better than a lead sheath. When a new communications cable recently had to be installed for the Berlin subway, for instance, an aluminum-sheathed cable was chosen for this specific reason.

In contrast to electrified railroads, three-phase current lines do not seriously influence communications cable unless single or double shorts-to-ground develop. To protect communications lines and their users from these brief effects, electricity supply companies frequently choose aluminum-sheathed communications cable. Although magnetic interference is also usually accompanied by a direct hazard due to the voltage cone at the point of the short-to-ground, this can likewise be overcome by choosing a cable with a small reduction factor. In this connection we supplied 46 km of aluminum-sheathed

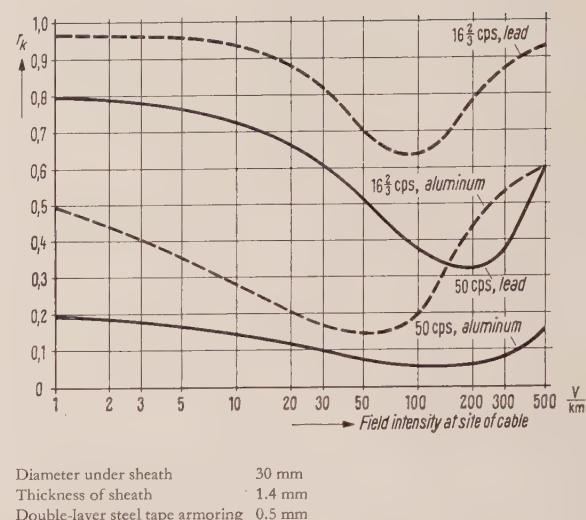


Fig. 2 Comparison of reduction factors r_k of lead-sheathed cable and aluminum-sheathed cable of same dimensions at 16^{2/3} cps and 50 cps

cable for Interconexión, Buenos Aires, two years ago and have now received a new order for a further 25 km.

Interference by high-power transmitters

If a carrier cable runs close to a radio transmitter it must be expected that the carrier channels will be disturbed in the frequency range of the transmitter. Although LW and MW transmitters broadcast with vertical polarization, longitudinal field intensities develop along the cable on account of the finite conductivity of the ground. Although considerably diminished by the metal sheath of the cable, a portion of the external field intensity penetrates the cable and is liable to disturb coaxial or balanced carrier lines operated with receiving powers of only a few picowatts. The determining factor for reducing field in-

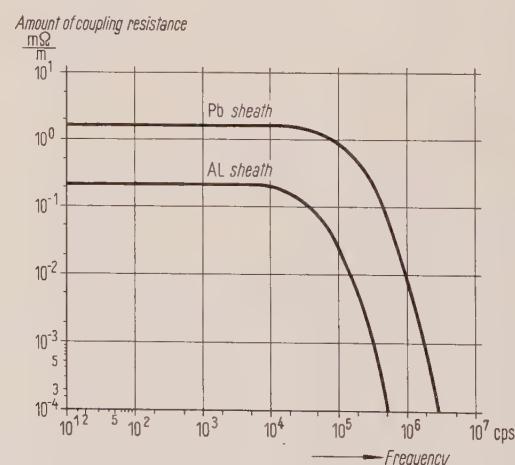


Fig. 3 Amount of coupling resistance of lead-sheathed cable and aluminum-sheathed cable as a function of frequency; sheath dimensions as in Fig. 2

tensity in the cable is the coupling resistance of the cable sheath [6]. Here again aluminum-sheathed cables will secure interference-free transmission by virtue of their very low coupling resistance (Fig. 3). For this reason an aluminum-sheathed long-distance carrier cable was chosen, for instance, for the route linking Freimann and Freising in Bavaria.

Lightning hazards

Lead-sheathed cables are sometimes destroyed by lightning, the length of the destroyed section often being very great [7]. Cables that, as with antenna systems, lead to an exposed point, are particularly endangered. This may be demonstrated by the example of a district cable belonging to the West German PTT that was run to a point in the Harz mountains. As the cable developed frequent faults throughout the year, the PTT decided to replace it with a new lightningproof cable. Although installed three years ago, this aluminum-sheathed and double-armored cable has not so far developed a single fault due to being struck by lightning. A district cable with the same make-up has been run between Freiburg and Todtnau in the Black Forest. Let us compare this with the measures taken by storm-prone countries like South Africa to protect their cables. Buried cables are there drawn into steel conduits that are welded together over long routes, a method that is not only expensive but also very troublesome with respect to installation and repairs.

Aluminum sheathing for aerial and bridge cables

The advantages offered by aluminum sheathing for aerial cables are its good conductivity, mechanical strength and low weight. The good conductivity gives self-supporting aerial cable a very large measure of protection against electromagnetic interference and lightning hazards. Further advantages of greater importance to aerial cables than to buried cables are the low weight of the aluminum sheathing and its vibration strength. The latter is also of great importance to bridge cables, which are known by experience to be subject to continuous vibration. In this respect aluminum is even superior to heavily alloyed lead. Normal cable lead is not suitable in such cases because it is only lightly alloyed and vibration is therefore liable to bring about a deformation of its crystal structure. Cracks then develop at the interfaces of the coarse crystals that form in the lead sheathing. This phenomenon is known as the intercrystalline brittleness of lead. Bridge cables are for this reason sheathed today almost exclusively with aluminum, steel or plastic.

Mechanical protection of cable core

Other advantages of aluminum sheathing are its cross rigidity and resistance to pressure. As a result of these two features it protects pressure-sensitive cable cores — among which high-grade coaxial lines must be counted —

far better than lead sheathing. This has also been demonstrated in practice. For instance, a carrier cable with a coaxial line (type 17) of the type widely used by the West German PTT exhibited no installation damage at points where it was provided with aluminum sheathing to prevent interference, whereas in lead-sheathed sections of the same cable the coaxial line was sometimes found damaged due to pressure in one form or another.

Applications and experience

Summarized in the order of their technical and economical importance, the advantages of aluminum sheathing over lead sheathing are as follows:

- a) High conductivity — offering the best protection against interference through powerlines, high-power r-f transmitters and lightning.
- b) Insensitivity to vibration — essential for bridge and aerial cables.
- c) Low specific gravity — an advantage for aerial cables and for the transportation and installation of buried cables.
- d) Good cross rigidity — offering pressure-sensitive cable cores better protection than lead sheathing.

For the applications described, these advantages of aluminum sheathing outweigh its drawbacks to such an extent that it has already found widespread introduction for communications cables. Initial misgivings regarding corrosion, soldering, and flexural stiffness have since been rendered groundless by the use of a reliable double-layer for protection against corrosion and by practical experience gained in cable laying and sleeve mounting. At any rate, since the use of this corrosion inhibitor and the appropriate training of installation personnel, Siemens aluminum-sheathed cable systems have not been known to suffer any type of damage that could be due to the properties of the aluminum. Our experience over many years confirms that, if well-designed, carefully fabricated and properly installed, aluminum-sheathed communications cables can be a great asset.

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Control of the Twin Drives of a Plate Mill

BY OTTO MARTIN, CLAUS SCHENDEL AND HANS SEYFRIED

The transistorized control equipment with slide-in tray units developed by the Siemens-Schuckertwerke has also found widespread application with drives of the high ratings. The article contains a description of the control of the twin drive for the four-high stand of a 4.2 metre plate mill and of the technological requirements to which the equipment was designed.

Each of the motors of the twin drive (Fig. 1) has a cut-out torque of 230 t-m at a cut-out peak load of 9,400 kW. The armatures are fed from single-anode mercury-arc converters in inverse-parallel connection. The motor fields are also excited by mercury-arc converters.

Fig. 2 is a block diagram of the entire control system. The speeds of the top and bottom motors are controlled separately via the armatures by two completely identical systems and their armature voltages are limited via the motor field in the field weakening range. The motors are coordinated via the common starting controller (1) and the armature current equalizer (2). The speed controls are transistorized [1, 2]. Each major time constant and

each important quantity of the overall system has its own subsystem. The controllers are therefore of simple design and can be easily adjusted so that definite cut-offs can be achieved under steady-state and transient conditions by simple means. In the case in question there are three cascaded controllers, namely for armature current control, acceleration control and speed control. In each case the reference input signal is supplied from the preceding controller.

The two branches of the inverse-parallel circuit have separate current controllers (8) and (9). This arrangement makes it possible to include the circulating current flowing in the anti-parallel circuit in the control. The controllers are practically instantaneous and act upon the mercury-arc converters via the transistorized grid control units (10 and 11) [3]. The actual current values I_{A1} and I_{A2} are detected by Hall current transformers (12 and 13) isolating the control and power circuits [4]. The proportional plus integral-action controllers are matched with the armature circuit time constant and the

Fig. 1 The two motors of the twin drive. In the upper storey of the switching station can be seen one of the control panels in line with one of the mercury-arc converters



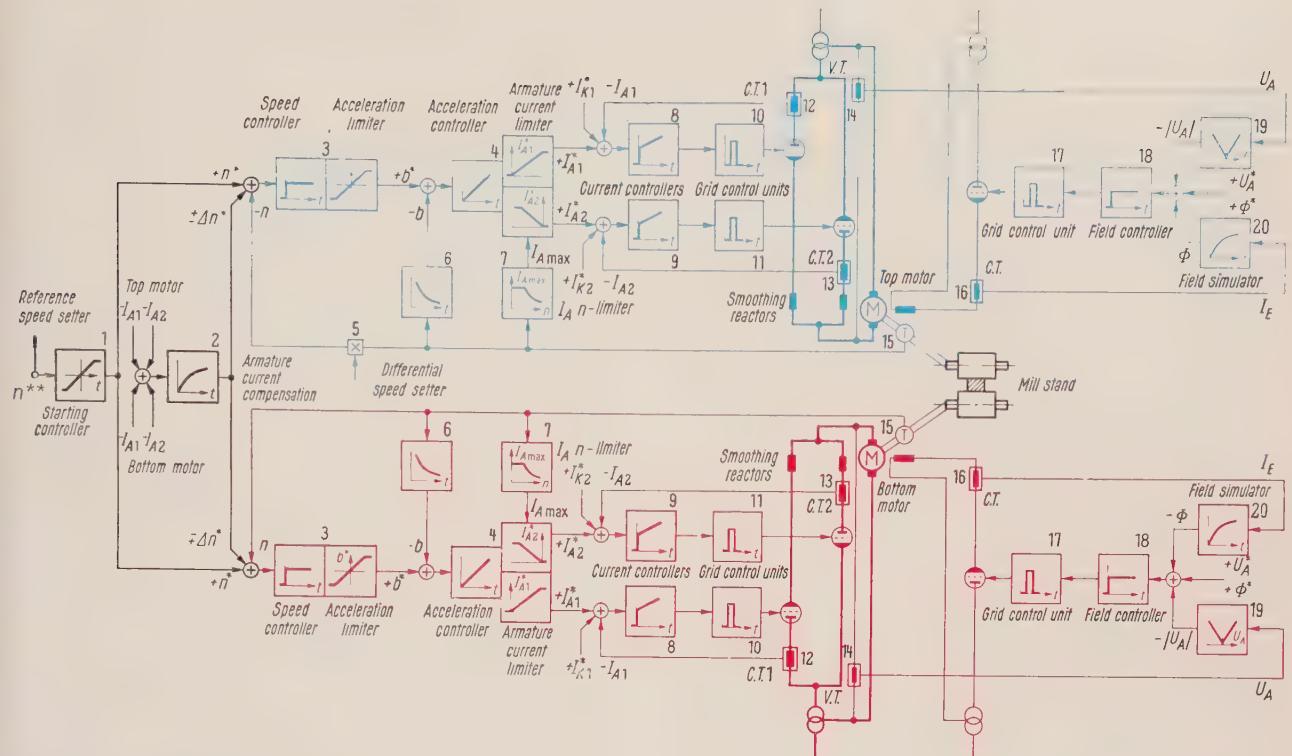


Fig. 2 Block diagram of the control of a twin drive

statistical dead time of the mercury-arc converters and make possible a rise time of about 10 millisecs. for the current (see Fig. 3). The current reference values I_{A1}^* and I_{A2}^* are supplied as unidirectional signals from the preceding acceleration controller (4). Independent of this, each current controller receives a constant circulating-current reference signal I_{K1}^* and I_{K2}^* . When control has been applied to one system, control of the other parallel-cascade system follows due to the effect of the circulating current, so that the armature current can be reversed without dead time. Limiting of the current reference value gives the desired cut-off current accurately and rapidly. This permits better utilization of the drive since, unlike with magnetic-amplifier controllers, it is possible to do so to full capacity without having to fear that the breakers will trip. Excessive current rise is avoided when the stock enters the rolls and shock loads on the system are thus substantially reduced.

The I_{An} limitation (7) has the effect that the commutation current limits are not exceeded in the case of large d.c. machines. Above a definite speed the product I_{An} must remain constant, i.e. the current must be reduced in inverse proportion with the speed n . The hyperbolic curve is replaced by straight lines.

In order to prevent the drive coming to standstill at maximum armature current, the current limiter is cut out shortly before standstill so that the protective breakers

can trip. Under normal operating conditions, this only happens in the event of excessive screw-down due to an error by the operator. As long as this error is not too great, the material can generally still be passed through the rolls at reducing speed by utilizing the kinetic energy of the drive and due to the reduction in the working torque required at low speeds.

The actual value b for the acceleration controller (4) which is of the integral-action type, is formed by differentiation (6) of the tacho-generator voltage (15). The reference value b^* is supplied from the speed controller (3). This quantity is limited in magnitude, so that limitation of the acceleration is also achieved. This is necessary in the event that rolling is carried out when current limiting has become effective. The reference and actual

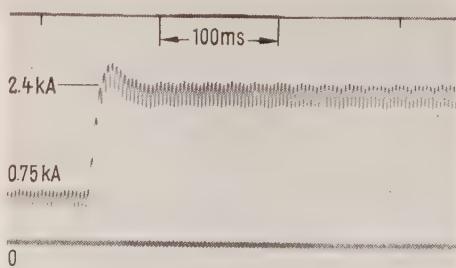


Fig. 3 Step function response diagram of the current control

values for the speed then do not coincide, since the rolling speed has been reduced by the current limiter. On removal of the load, the cut-off current would cause the drive to accelerate too quickly to the set speed. The acceleration limiter spares the mechanical parts of the drive and is set high enough to prevent the rolls from becoming damaged.

With the twin drive the speed control permits synchronous control of both motors and also makes possible accurate adding of corrective signals. The actual speed n is supplied from the tacho-generator (15). The speed controller (3) has a proportional-action characteristic and its gain is matched with the mechanical time constant. Owing to the integral control of acceleration, however, the speed control remains astatic. (Both controls together have the effect of a proportional plus integral-action controller).

The reference speed n^* is supplied from the common starting controller (1) which uniformly controls both the top and bottom motors in every operating condition, including reversing. It converts the reference value n^{**} set on the control pulpit into an acceleration-limited signal and governs the acceleration performance of the drive. This is required mainly by the limitation imposed on the acceleration of the material through the roller tables. It is also possible with the starting controller to vary the settings of the accelerating and retarding periods should this be desired for operational reasons.

The armature current equalizer (2) produces the difference between the armature currents of the top and bottom motors from the four branch currents of the installation. If the speed controllers are subjected to opposing compounding actions $\pm \Delta n^*$, which must be introduced with time lag for dynamic reasons, a load

compensation, the degree of which is adjustable, is achieved between the two motors.

The differential speed setter (5) makes it possible to set different speeds for the top and bottom motors. This is mainly effective during no-load operation until it is neutralized after a certain time lag by the load compensation. In this way external disturbances, such as unequal roll diameters, varying temperature distribution and the effect of the roll opening, can be compensated within limits. The differential speed setter also affects the load distribution via the proportional offset of the load compensation.

In the range of the base speed the field current is controlled at its rated value, independent of the a.c. system voltage and temperature rise in the field winding. The field controller (18) acts upon the field rectifier via a transistorized grid control unit (17). The actual field current I_E is detected by a Hall current transformer (16) isolating the power and control circuits. The field simulator (20) takes into account the damping effect of the machine which is unavoidable due to the armature windings short-circuited by the brushes under the poles even in machines with laminated field structure to diminish eddy currents. The output signal of the field simulator represents an actual quantity which corresponds dynamically to the flux Φ . Transition to the field weakening range is by constant armature voltage control (rated voltage) via the motor field. Since the voltage and flux behave dynamically approximately in the same manner, the same field controller can be used. The absolute value of the armature voltage (19) which is detected by an isolating voltage transformer (14), is supplied to a field controller as second input signal of an actual value. This input signal takes over from the first when the rated armature voltage is exceeded and makes the field current control inoperative. In the first case the constant desired value denotes the desired flux value Φ^* , and in the second case the desired armature voltage value U_A^* .

This type of field control has several advantages. Small speed errors are rapidly corrected in the armature circuit, the field control preventing the occurrence of excessive armature voltage. If, in the field weakening range of the drive, the armature current reaches the permissible value, the armature current limiter quickly takes effect via the armature circuit and the field of the motor is strengthened due to the speed dropping at full armature voltage. This causes the driving torque to increase to the desired rolling torque and the rolling speed adjusts itself automatically to the maximum possible value at this torque. Erroneous speed settings can therefore no longer have an adverse effect and the rated motor output can be fully utilized at rated armature voltage and with a good power factor. If the current limiter of one motor becomes operative under unbalanced load conditions, the other

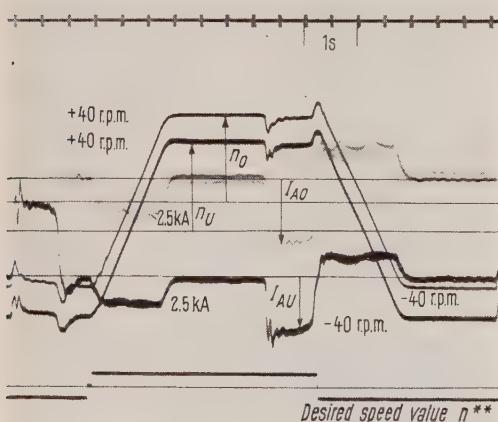


Fig. 4 Speed and armature current curves of both motors on a load surge followed by a reversing operation

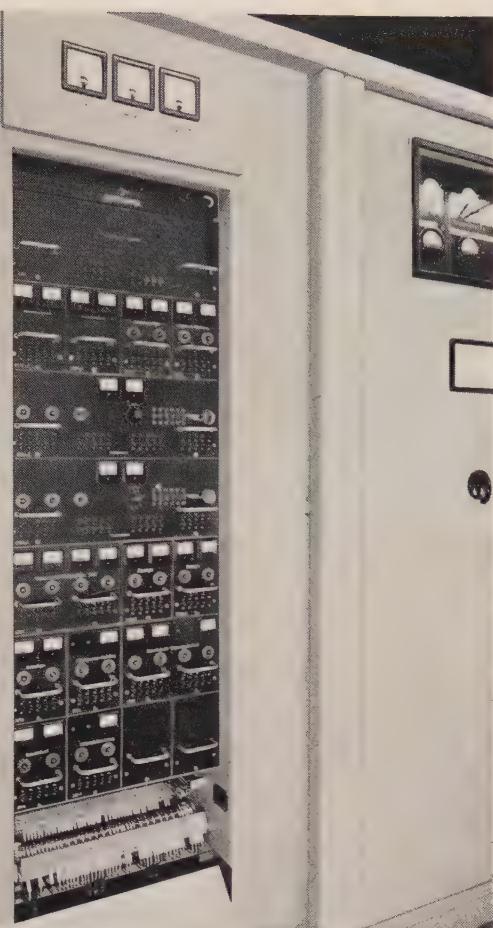


Fig. 5 Control panel with slide-in tray units for the armature control of the bottom motor

motor takes over the excess load until its cut-off current is also reached. Consequently, in addition to the partial load compensation, utilization of the total torque of the twin drive is guaranteed.

The oscillogram (Fig. 4) shows the speed and armature current curves of both motors on the occurrence of a load surge, the removal of load being followed immediately by a reversing operation. The new reference speed value n^{**} was applied abruptly. It can be seen from the oscillogram that the mechanical parts of the drive, which comprise mainly the inertia masses of the motor, the driving shaft and the working and backing-up rolls of the stand, form a vibrational system which can be excited on the occurrence of sudden severe torques.

Fig. 5 shows a controller panel of the slide-in tray type [5]. According to the individual control functions the control elements are distributed over the various trays. Measuring instruments and test sockets on the front plates facilitate supervision. Faults can be quickly localized and readily cleared by simply replacing the slide-in tray.

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Development of the SABENA Teleprinter Network

BY SERGE LEBRUN

Without going into the details of telegraph history, a short review makes it clear that telegraphy and modern transportation are parallel developments. When the first trains appeared in the first half of the 19th century, telegraphy experienced its first boom. The rapidly growing railway companies were given the right to operate their own telegraph systems. When commercial airlines entered the picture in the years after 1920 (Fig. 1), separate networks were set up again. These, too, expanded rapidly as the airlines succeeded in securing a sizable and ever increasing share of the total, continuously expanding world traffic.

These telegraph networks transmit millions of messages a year. The problem is that speed of transmission must

keep abreast of the ever increasing cruising speed of airplanes. Any appreciable congestion in message transmission, not unlikely with the present switching methods, would impair economic operation. Cruising speeds soared up when the first jet planes appeared in international air traffic end of 1958. This brought about revolutionary changes at a tremendous pace, in particular when viewed from the angle of transport capacity.

Two years later, i.e. as early as end of 1960, jet planes accounted for more than 50% of the total capacity of world air traffic. Some hold that this figure will rise to 75% or even 80% during this year.

This compelled major airlines to contemplate the automation of some of their most essential functions.

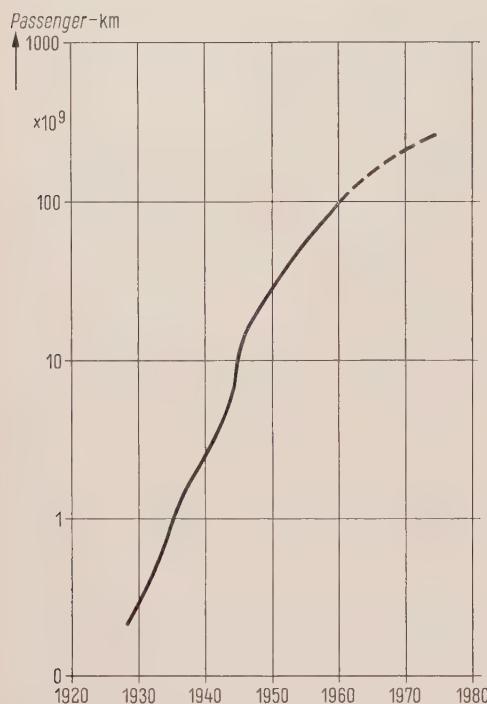


Fig. 1 Development of commercial air traffic from the very beginning to the present

The SABENA*, for instance, started to plan automation of its manual switching system well back in 1956 as manual message handling became increasingly difficult in view of the ever growing traffic volume. Fig. 2 outlines the teleprinter traffic of the SABENA during the years from 1954 through 1960. A spectacular peak was reached in 1958 on the occasion of the Brussels World Fair.

Disregarding this 1958 peak, the message volume of the SABENA shows a continuous sharp rise so that the 1960 figure is four times that of 1954. With a view to economy it may be said that adoption of automatic switching is fully justified already today.

Since, on the one hand, the telegraph traffic of airlines differs greatly from the teleprinter service of postal administrations and, on the other hand, traffic was not such as to make a rapid decision imperative, Siemens & Halske started out with a basic analysis to determine the most suitable system for the SABENA. As a result of these investigations one incoming line was automatized early in 1957. The messages arriving over this line could be distributed automatically to a total of 5 outgoing lines. The storage media were perforated tape machines.

After 12 months of successful trial operation, a larger automatic section (6 incoming and 20 outgoing lines and tape storages) was added in May 1958 to the manual center. This was done in anticipation of the sheer volume of traffic which was to be expected in connection with

the World Fair. The results were again very satisfactory but, unfortunately, these facilities were destroyed in November 1958 in a fire which swept part of the new airport Bruxelles-National. Thanks to the immediate support from the Belgian RTT** and Siemens & Halske, the center was very soon restored to service with provisional telegraph facilities made available by Siemens & Halske within a few days.

These preliminary facilities have now been replaced by the large new teleprinter center which was cut over to service in March 1961 in the new terminal building of Bruxelles-National (Fig. 3). This is the first message switching center of a European airline in which a large portion of the traffic is processed on a fully-automatic basis. The control circuits are fully-electronic. Transistors and magnetic tape units are predominant system components. This center has been designed to provide the criteria specified by the SITA*** for the sake of compatibility. The Brussels center of the SABENA is a link in the chain of message centers forming the SITA network. This network interconnects all of the major airports in the world.

It was found advisable to automate, for a beginning, only part of the incoming lines. This is only a precautionary measure. Fully-automatic operation makes it imperative to adhere to a specific message format. The message proper is preceded by the socalled message head which includes a number of control signals for routing the message within the center to the desired outlet. Compliance with this format presupposes thorough training

** RTT Régie des Télégraphes et Téléphones

*** Société Internationale de Télécommunications Aéronautiques

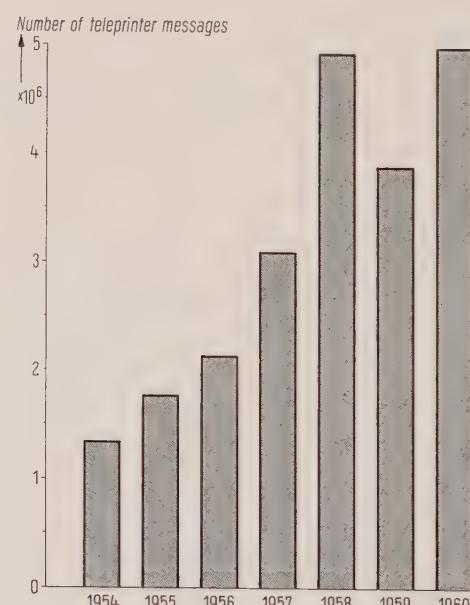


Fig. 2 The teleprinter traffic of the SABENA during the past 7 years

* Société Anonyme Belge d'Exploitation de la Navigation Aérienne



Fig. 3

Airport Bruxelles-National. The terminal building in the background also houses the message switching center of the SABENA

and attention to detail on the part of the attendants staffing the connected tributary and terminal stations of the network.

Considering the fact that the format (ATA/IATA*) has so far not been officially established or definitely introduced in the SITA network and being aware of the difficulty of ensuring compliance with the format in each and every case, only 14 incoming lines have so far been automated. Cross-office switching is accomplished with the aid of a 2-digit routing code specifically designed for this center. The remaining incoming lines are terminated in the semi-automatic section of the center where the problem of the message format is only of secondary importance.

At the present stage the message switching center comprises a fully and a semi-automatic section. Automation of the semi-automatic incoming lines at some later date can

be carried out any time and without difficulty. Switching centers of larger capacity can also be based on this operating principle, which has been described in more detail in another paper also published in this Review¹. The new message switching center of the SABENA in Brussels, now occupying a floor space of 214 square meters, has been rated to handle safely the traffic volume expected in 1963.

The fact that we have now a switching center in Brussels in which the most important lines are already automated is to a large measure due to the active support by the Belgian RTT and the smooth cooperation between the SABENA and Siemens & Halske.

* ATA Air Transport Association
IATA International Air Transport Association

¹ Graf, W.: The Teleprinter Switching Center of the SABENA for Fully- and Semi-Automatic Operation. Siemens Review XXVIII (1961) pp. 205 to 210

The Teleprinter Switching Center of the SABENA for Fully- and Semi-Automatic Operation

BY WINFRIED GRAF

Air traffic requires a voluminous exchange of communications between airports and between the offices of the airlines. Most of these communications are sent in written form. Messages which are connected specifically with air traffic include seat reservation requests and operational communications. The big airlines with stops in all parts of the world have rented world-wide teleprinter circuits to serve their communication needs. These circuits frequently form part of the SITA net-

work and are jointly used by a number of companies. Some companies, however, operate their own circuits. The Belgian airline SABENA whose new teleprinter switching center will be discussed in the following operates also its own circuits linking, for example, Brussels with Léopoldville and New York [1].

A characteristic feature of this traffic is the fact that many messages do not require an immediate reply. A large per-

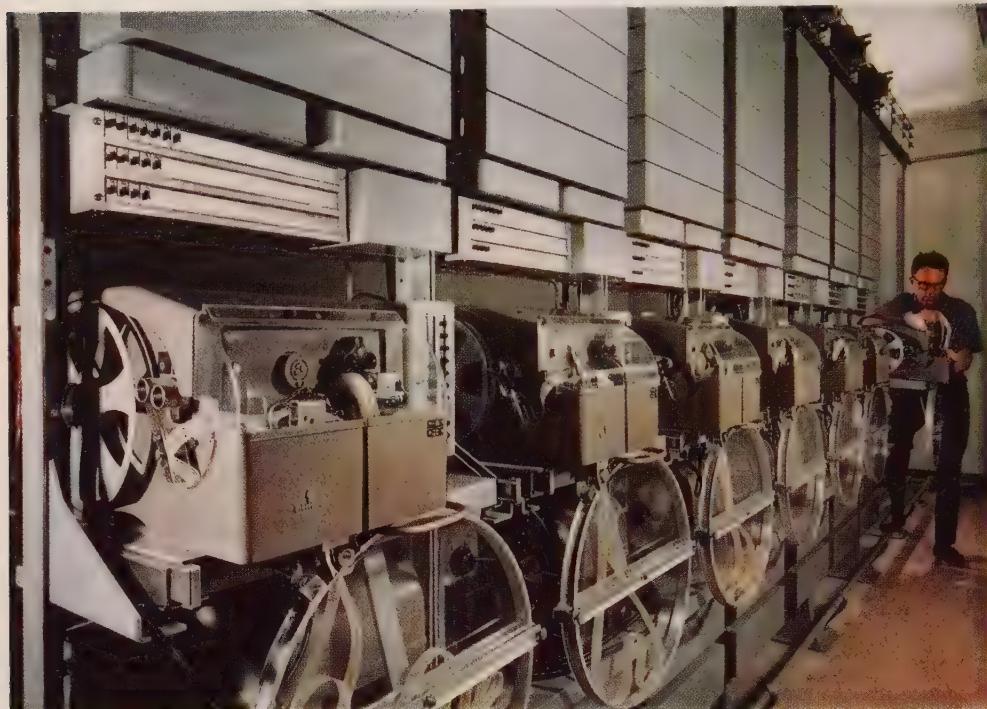


Fig. 1 Rack row with incoming line units

centage of the total traffic must be routed to a number of destinations simultaneously (multiaddress messages). Either purpose is served particularly well by a message switching center. Networks employing this type of switching center afford a high degree of line utilization and this is a point whose importance cannot be over-emphasized in view of the extensive and therefore expensive line plant.

The use of message switching centers obviates the necessity of establishing a through-connection from the message originator to the destination. Instead, messages are transmitted over that section which happens to be free. If the following section is occupied, they may wait until it is cleared. Moreover, the two directions of a route may be operated independent of each other (full-duplex) with a resulting increase in capacity by a factor of 2.

The Brussels switching center of the SABENA

The new SABENA center is intended to replace the old teleprinter exchange which was no longer capable of coping with the ever increasing traffic load. It is accommodated in the new terminal building of the Bruxelles-National airport and serves chiefly the communication needs of the SABENA. On the input side, the new center permits the connection of 14 lines for fully-automatic and 24 lines for semi-automatic traffic. On the outgoing side, 53 send lines are provided. Twenty local stations are connected to 2 of the 24 incoming lines by way of a concentrator as the low traffic volume of these lines would not justify individual termination. Accordingly, two lines provide access to the same stations through the con-

centrator on the outgoing side. Messages which cannot be retransmitted immediately are temporarily kept in cross-office storages, of which 16 are provided. These can be connected with all incoming and outgoing lines.

Fig. 2 represents a simplified block diagram of this switching center. Each fully-automatic incoming line terminates in an incoming line unit which is immediately through-connected to the outgoing line unit when the desired line is free. If the line is busy, the incoming line unit is connected to a cross-office storage which holds the message until the desired line becomes idle. When this line is cleared, that cross-office storage whose message has been waiting longest will be the first to be connected to the outgoing line unit.

The semi-automatic incoming lines terminate on typewriter reperforators. Messages are switched on the torn-tape

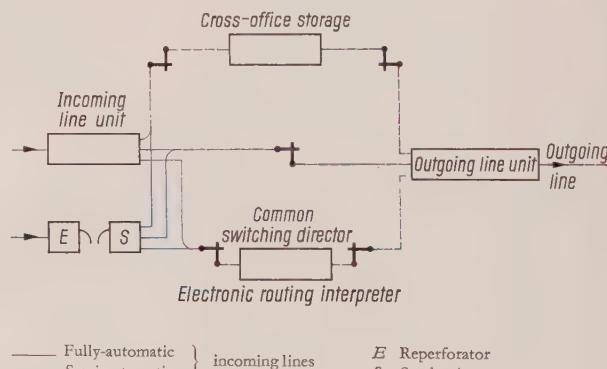


Fig. 2 Schematic block diagram of the message switching center

principle. The tape containing the message is torn off after receipt of the end-of-message signal and fed into a tape reader after the desired line has been marked on a destination button- and lamp panel. The message is retransmitted immediately either directly into the desired line or, if the line is occupied, into a cross-office storage.

The necessary internal connecting processes are controlled by common switching directors. Interpretation of the address, on the basis of which the message arriving over a fully-automatic incoming line is retransmitted, is the function of a common electronic routing interpreter. The interconnecting media are noble-metal high-speed relay multi-switches (relay couplers) which establish a connection in the extremely short period of about 2 milliseconds (Fig. 3) [2].

Operating principle of the fully-automatic section

Further details of the switching center are shown in Fig. 4. The incoming line unit terminating a fully-automatic receive line comprises a receive section and a send section which are interconnected by the storing medium (perforated tape). The receive section of this unit is always ready for reception so that no message can get lost. The perforated tape feeds from the receive section into the send section where the address in the message head is read and subsequently stored in an address memory. The incoming line unit then associates itself by way of relay coupler *ECK* with one of the two common switching directors and transfers the address at a higher than the normal transmission rate. The address translator of the switching director translates the 5-unit code into a letter code and transfers the address to the common electronic routing interpreter which marks the desired send direction. This results in a corresponding setting of relay coupler *MAK*. Interpretation of the address and setting of the marking coupler *MAK* are accomplished at so high a speed that a single routing interpreter will easily serve the entire center.

If the desired outgoing line is idle, the switching director connects the send section of the incoming line unit by way of relay coupler *ELK* with the outgoing line unit and then disconnects from the incoming line unit. The message is now read out of the incoming line unit and is routed over the above described internal path into the next section of the network. Relay coupler *ELK* returns to normal upon detection of the end-of-message signal (*EOM* signal) in the send section of the incoming line unit.

If the switching director finds the outgoing line busy, the message is passed on to a cross-office storage. The switching director checks whether one of the storages has already been set to the required line and whether its input is accessible. Such a storage may already

contain one or more messages destined for the marked route. If this check is positive, this storage is connected. If not, any other free cross-office storage is seized and associated with the send line by way of relay coupler *RIK*. At any rate, a connection is established between the incoming line unit and a cross-office storage through relay coupler *EZK*. Thereupon, the switching director dissociates itself. The incoming line unit in which the message has been waiting during the switching processes will now transmit the message to the cross-office storage. The input and output sides of the cross-office storage are functionally independent so that retransmission over a line just becoming free may commence before the message is completely received.

When a send line becomes free to which one or more cross-office storages have been set, the read-out allotter goes to work and selects that cross-office storage whose message has been waiting longest. It is connected with the outgoing line unit through relay coupler *ZLK* for transmission into the send line. The connection between the storage and the line is separated after detection of the *EOM* signal. With a number of messages waiting for the same line, this allotting cycle starts over again after the first message because it may now be the turn for another cross-office storage to transmit the message

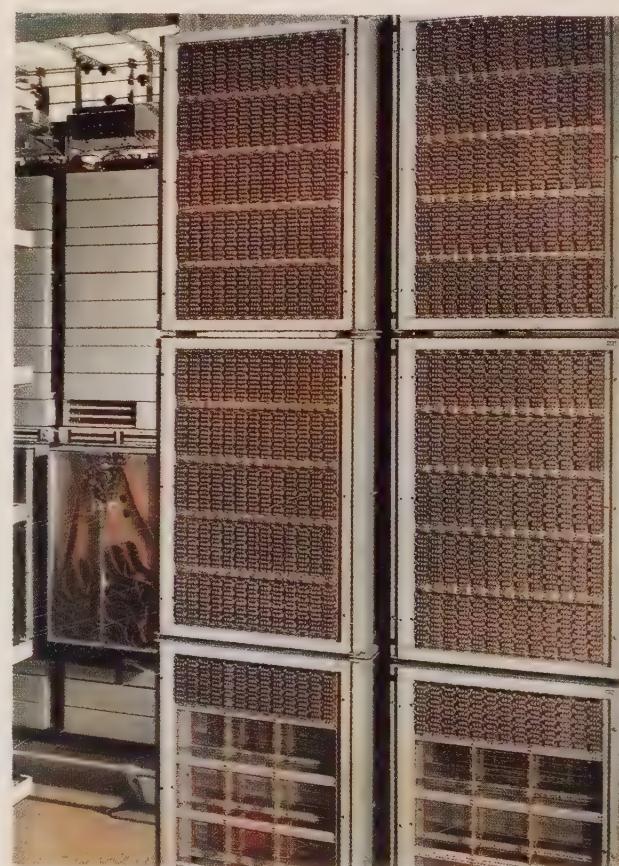


Fig. 3 Racks with relay couplers

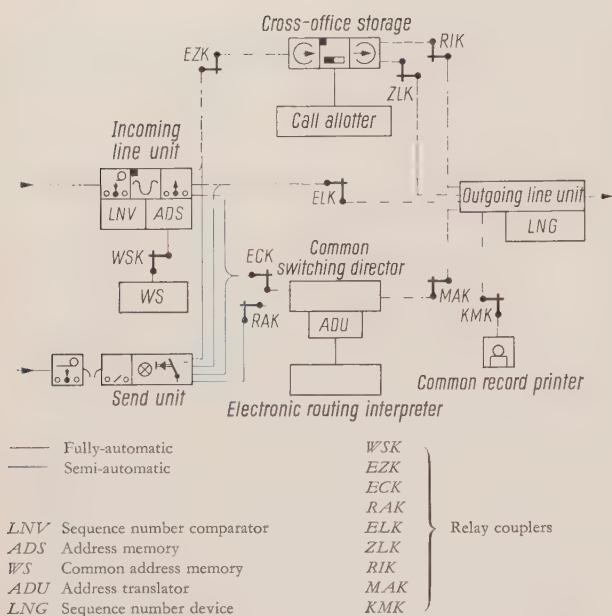


Fig. 4 Block diagram of the fully- and semi-automatic message switching center

which follows the first one in chronological sequence. When a cross-office storage has been completely emptied, relay coupler *RK* is released. The storage is now available for taking over a message destined for another occupied line.

The address memory in the incoming line unit is designed to hold only one address. In the case of multiaddress messages, a common multiaddress memory is therefore connected through coupler *WSK* to the address memory of the incoming line unit for the time the connections are set up. This memory accepts the second and all further addresses. Since the multiaddress message has to be transmitted into a number of outgoing lines, the common switching director connects, for each individual address, a free line or a cross-office storage to the send section of the incoming line unit. The incoming line unit then transmits the message simultaneously to all of the connected lines and/or cross-office storages. This arrangement ensures that such messages can be retransmitted independent of the time the individual lines become available. It results in the shortest possible instation transfer time.

Operating principle of the semi-automatic section

The messages are here reproduced in the form of perforated tape with monitoring print. One typing reperforator is permanently assigned to each incoming line. These machines are accommodated in cabinets within easy reach of the switching attendant. Each operating position is equipped with 8 tape readers for retransmitting the messages.

The tapes are torn off at the machines after receipt of the end-of-message signal. The operator reads the address

and marks the required outgoing line by pressing the associated button on the destination button panel of his control console. For switching multiaddress messages a corresponding number of buttons has to be operated. The tape strip is then fed into an idle tape reader and the start button operated. The control circuit of the respective send unit automatically advances the tape to the proper code combination (start-of-address) and then requests the services of a switching director with which it is connected through relay coupler *ECK*. The routing information stored in relay coupler *RAK* is transferred to the switching director which now takes over through-connection to the outgoing line unit or to a cross-office storage (couplers *ELK* and *EZK*, respectively), similar to the processes taking place in the fully-automatic section. As the message is transmitted, the tape drops into a chute located behind the tape reader. Upon detection of the *EOM* signal, the connection is cleared. The tape strip remains held in the tape reader to have it still at hand should this become necessary for one reason or another.

Message handling safeguards

A number of supervising and monitoring facilities have been provided to prevent loss of messages in spite of one-way traffic and section-by-section transmission. The well proven sequence number check has been adopted on the line sections between the individual centers and between the outstations and the center. Starting at midnight, all messages are consecutively numbered. Each line section has its own set of sequence numbers. The sequence number, together with the line identification and some other function signals is transmitted, ahead of the message proper, by a sequence number device assigned to each outgoing line unit. When a message arrives in the center, the sequence number may automatically be checked by the sequence number comparator in the receive section of the incoming line unit.

Within the center all wires carrying intelligence signals are continuously supervised. Any faults occurring within the center are signalized. Power outage will not result in messages getting lost in the storage media. Also the magnetic tape storages erase the information only during recording.

The supervisor's position is afforded immediate access to all lines and storages. The position of the sequence number devices and sequence number comparators can be visually displayed. The coupler supervision permits a check on which coupling points are through-connected at a given time. The message volume in the different storing media is under constant scrutiny, one storage load counter being assigned to each storage. Counter readings can be displayed individually or totalized for a certain send direction. Common monitor printers are automatically connected through relay couplers *KMK* to the outgoing line units. They prepare a record not

only of the message head but also of internal check characters which identify the incoming line unit or the send unit, the switching director, a cross-office storage which may have been used, and the time of transmission. This internal process surveillance information plus synoptic message information permit easy tracing of all messages.

Constructional layout

The switching center facilities are distributed among three rooms. Accommodated in the operating floor are three operating positions with the reperforators and the control consoles for semi-automatic operation. Each position terminates 8 incoming lines on the same number of reperforators. The latter are contained in noise-absorbing housings. Messages are switched on the control consoles. Recessed into the lower section of the control panel are the 8 tape readers. The destination button panel in the center provides access to each outgoing line. The lamp panel on top gives an indication of the selected send line. If the send line is busy, the message is passed on to a cross-office storage.

The tape readers are controlled by one of the common electronic send distributors which, in addition to their timing function, take care of the formation of teleprinter signals. The space-saving and compact design of the tape readers permits all operations to be performed in a sitting position. For service traffic with the distant station a pageprinter placed beside the console may be connected direct to the send lines corresponding to the receive lines terminated at this position. The supervisor's position as well as the common record printers

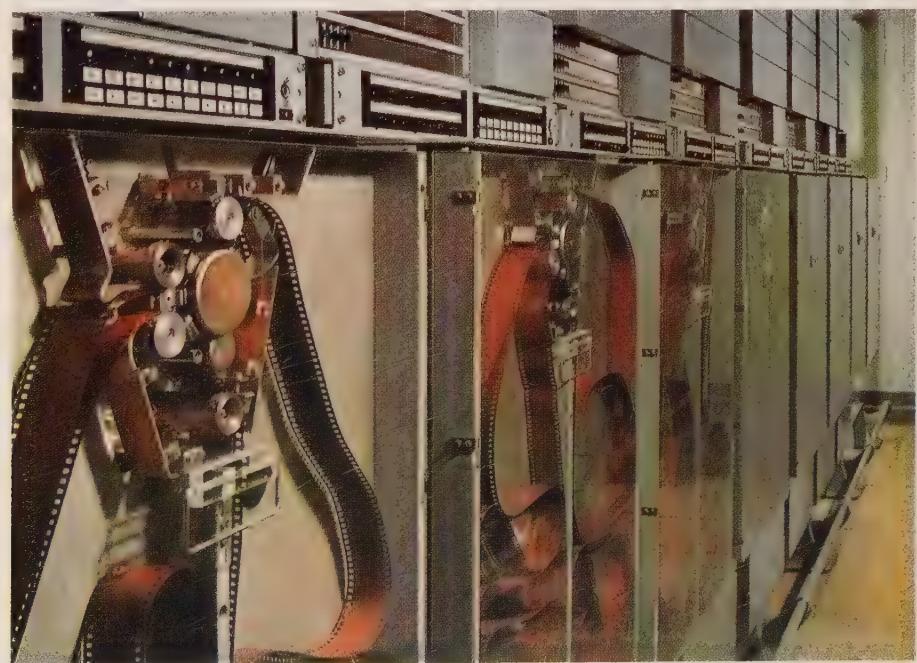
are also accommodated in this room together with the concentrator position.

The rack room includes the switching facilities and the storing media in the well proven rack design. The incoming line unit which terminates a fully-automatic line comprises a combination of a typing reperforator and a tapetransmitter with sequential output, a so-called typing reperforator/transmitter-distributor, and a tape storage magazine. At this point of the switching center all messages are available completely in written form for checking purposes. The lower section of a rack contains two reperforator/transmitters arranged back-to-back. The machines can be pulled out for renewing the paper supply rolls. The upper section houses the associated relay circuits (see Fig. 1). The incoming line units, which require a certain amount of servicing, are grouped in a separate aisle.

Contrary to the storage in the incoming line unit, which is a paper tape storage, the cross-office storage is a magnetic tape storage, i.e. an electronic regenerative storage. The storing medium is here an endless magnetic tape whose storing capacity of 4,000 signals corresponds to about 20 average-length messages. Signal read-out is timed by crystal-controlled common electronic send distributors. A cross-office storage rack comprises two complete storages with the associated control circuits (Fig. 5).

The power supply equipment is housed in the third room. It includes the ordinary 60-0-60 volt rectifiers since no special requirements need to be satisfied as regards voltage stability. In the case of a commercial power

Fig. 5 Rack row with cross-office storages



outage a small-capacity standby battery will bridge the gap until the emergency power supply units have taken over.

System expansion involves no difficulties of a technical nature. The components to be added, such as storages, line units, relay couplers, etc. can all be installed without interfering with current operations. If and when manual lines have to be automated, only the input units need to be exchanged while all other parts of the switching center remain unchanged.

Automated outstations

Strict compliance with the message format is imperative for a smooth traffic flow through a fully-automatic message switching center. The message format is the organizational set-up of a message. It determines the relative positions of the sequence number, address, message originator etc. within the message head. Certain function signals are intended for the control of the switching facilities. These include the start-of-address signal, end-of-address signal, start-of-message body signal and end-of-message signal. Experience has shown that even well trained personnel occasionally falls to follow the relevant instructions with the necessary care and diligence. This suggested the automation of the operator's task. Four heavily loaded send stations have been provided with equipment which automatically inserts the message head including sequence number and all function control signals. The desired address is selected on a 30-unit pushbutton panel. Only one destination

button needs to be operated for each complete address. The remainder of the message head including channel identification, sequence number, etc. is transmitted on a fully-automatic basis.

Forecast

The new message switching center went into operation early in March 1961. During the first month of its operation as many as 300,000 messages have been relayed although a number of lines had not yet been connected and traffic at this time of the year is far off the peak mark.

For the time being traffic is handled without precedence classification. Provisions have been included, however, to permit precedence switching if and when so desired. In the fully-automatic section the precedence status of a message is detected by the common routing interpreter reading a fixed code in the message head. In the semi-automatic section a precedence button is operated instead of the start button after loading the tape reader. The precedence prosign causes a message to be transferred into a cross-office storage having a priority rating when the desired line is occupied. When this line becomes free, the priority storage is the first to be connected. Provisions for interrupting a transmission in progress are not included.

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Supervisory Remote Control and Indicating Equipment for Traction Power Supply Systems

BY WALTER HENNING

As in the case of public and industrial power supply systems, supervisory remote control equipment has, in the course of the last 10 years or so, gained increasingly in importance for the power supply of electrified railways. Approximately 30% of the supervisory control systems supplied by Siemens-Schuckertwerke for this field of application in Germany and abroad are used for operating the traction power supply systems as economically and trouble-free as possible.

Apart from the remote control and supervision of supply substations, e.g. rectifier or system-tie frequency converter substations, this concerns particularly the centralized remote control of contact-wire switches [1].

Remote control and supervision of railway supply substations

The advantages of the remote control of railway supply substations are of both an economical and operational nature. The economical significance results from the fact that the substations concerned are unattended and consequently are simpler and cheaper in construction owing to the absence of accommodation and control rooms. The wages for attendants are also saved in the case of remote-controlled substations so that the supervisory remote control equipment generally repays its capital expenditure within a few years. Furthermore, the lack of trained reliable operators is making itself more and

more felt. Supervisory remote control makes it possible to employ the competent personnel available at central control points covering a wider area. From the operational point of view it is advantageous to supervise all functions of the individual substations of a power supply area from a central system control station and to have the necessary switching operations performed by trained personnel within a few seconds through remote control. Upon failure of a unit or in the event of system faults, this feature may be of great importance with regard to the maintenance of operation.

The first extensive supervisory remote control plant of this type was supplied as early as 1928 by the Siemens-Schuckertwerke for the remote control of about thirty rectifier substations of the Berlin Metropolitan Railway (Berliner Stadtbahn). This plant was equipped with motor-operated heavy-current step switches. Since then, however, remote-control uniselector equipments (Fig. 1) have been used almost exclusively for the transmission of remote control signals and supervisory indications. A detailed description of such an equipment is contained in another article [2]. By means of these devices, the control and indication signals are converted into coded impulse trains and operating faults or erroneous indications are thus precluded with certainty. Substations of any size can be remotely controlled and supervised via one pair of cores of a communication cable or via any other communication channel.

The transmission times of the Siemens-Schuckertwerke remote-control uniselector equipments for control and indication signals are never more than a few seconds, an indication impulse train of 3 seconds duration containing up to 28 change-in-position or alarm indications. Still shorter transmission times, which are of particular importance when a great number of control functions have to be carried out at a time, are obtainable with the recently developed electronic remote-control devices [3]. These devices operate on the pulse-code principle and require only about half a second for the transmission of a control signal, while the transmission of a large number of simultaneously available position and alarm indications takes about the same time as with the uniselector equipment.

In remote-controlled substations all circuit breakers of the railway transmission system and of the distribution system fed from the particular substation are generally controlled and supervised by means of supervisory remote control and indication equipment. Since these sub-

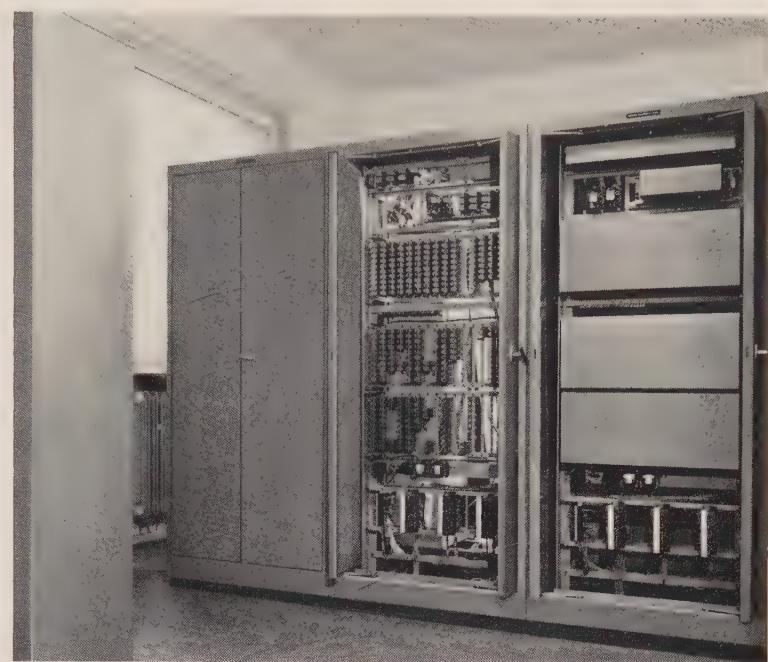


Fig. 1 Remote-control uniselector equipment in a central control point

stations are unattended, remote control is also provided for those isolating switches which, in the case of a bus transfer, for instance, have to be frequently and, above all, rapidly changed over. For all other isolators, particularly earthing switches, only remote indication is provided.

Remote indication must also be extended to include the conversion units in the supply substations, such as rectifiers, frequency converters or transformers. This requires the transmission of a number of alarm indications for each unit to inform the operator at the central control point of any type of fault or impending danger to which the individual rectifier, for example, may be exposed.

Finally, the functioning of the supply substation or the power supply of the traction system has to be supervised and this is best done by employing a remote metering system adapted to the particular requirements. The object is to inform the operator at the control point, for example, of the primary and secondary busbar voltage levels and of the magnitude of the individual and summed currents of the available rectifiers, frequency converters etc. For safe operation, selective readings of the feeder currents are also of importance, as is the remote testing of the contact-wire sections fed via the individual track feeder circuit breakers.

If the distance from the central control point is short and a sufficient number of pilot cores are available in the interconnecting cable, the individual measured quantities may be transmitted as continuous readings and, for

example, also recorded as summated values. If only a limited number of pilot cores is available, or if their provision becomes uneconomical for great distances, continuous readings or records of the measured quantities can be achieved by the use of multiplex transmission with audio-frequency equipments. The latter make possible simultaneous transmission of a maximum of 24 readings over one pair of cores; they can also be operated by adding and dropping of channels (way-station traffic). In the case of a very great number of continuous readings, cyclic transmission of the measured quantities is possible by using the time-multiplex method.

Generally, however, it is necessary to transmit and indicate continuously only a few readings. The other values, such as the individual feeder currents of a switching substation, can be combined into one "as-called-for" indication of several readings on a single channel. This makes it possible to select, by means of the uniselector equipments, one particular reading at a time and transmit it via a common transmission path as long as this is required.

The types of remote metering systems to be employed in each particular case differ widely, depending on the nature and length of the transmission path available. These have been dealt with in other articles [4, 5].

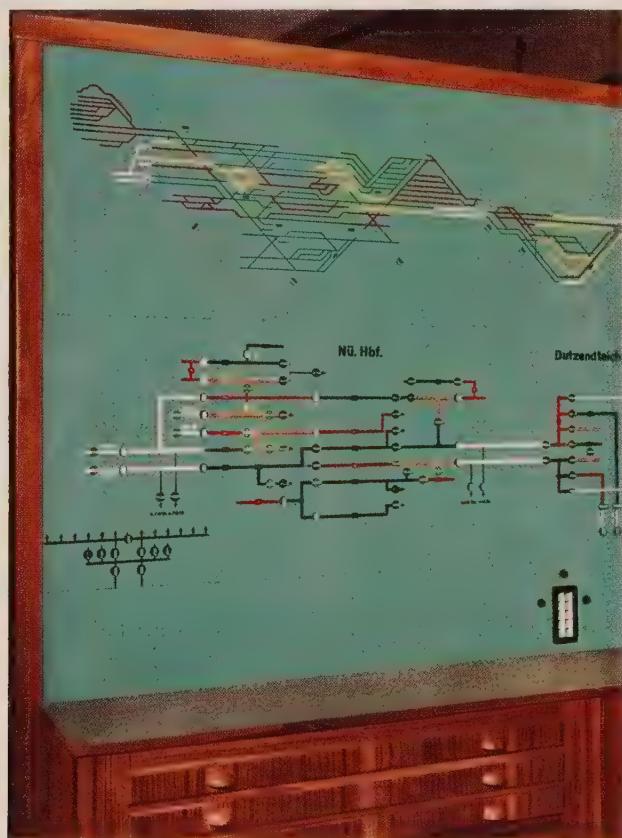


Fig. 2 Control board for the supervisory remote control of mast breakers with track diagram

The control panels at the central control point for the remote-controlled substations generally differ only slightly from those of manned, locally-controlled substations. For the remote control and indication of the circuit breakers and isolating switches, control discrepancy and acknowledgement switches of standard design are used, preference being given to those with small or miniature dimensions.

Remote control of contact wire switches

Another extensive field of application for the remote-control uniselector equipments in the railway traction power supply systems is the remote control of the section isolators. These isolators were formerly locally operated within a railway station area from the associated signal cabin on receipt of telephone instructions from the chief signal office or the supply substation.

On lines with heavy traffic, this type of instruction transmission by phone and the answer back that the respective operation has been completed has long been found to be too time consuming on the occurrence of disturbances or in the event of earth fault tracing and repair work. For this reason, the majority of section isolators are nowadays remotely controlled from a centralized control point. Another reason for this is the fact that in the field of railway signalling an ever-increasing number of central control stations is being installed for the switch and signal control of entire routes. This dispenses with the attended signal cabins formerly required on these routes. Thus the personnel formerly attending them can then be employed for the local control of mast switches.

Remote-control uniselector equipment is also given preference for the supervisory control of the contact-wire switches but in this case under special conditions. For example, only a single pair of cores is generally available on the communications cable running parallel to the route for supervisory control of the individual switch groups spread over the various station areas. The uniselector equipment must therefore be designed to transmit via one pair of cores the control and indication signals for as many as 10 breaker groups along the route.

The Siemens-Schuckertwerke remote-control uniselector equipment handles such line traffic in the following manner. Every time a control signal is transmitted for the operation of a switch of a particular group, the sending uniselector at the central control point transmits a control impulse train with a special long-time starting impulse to all receiving uniselectors connected in parallel along the line. Owing to the presence of an additional group criterion, however, the impulse train is evaluated only in the receiving uniselector via which the switch to be operated by the control signal is controlled.

An indication that the operation has been completed is re-transmitted following the changeover of the section

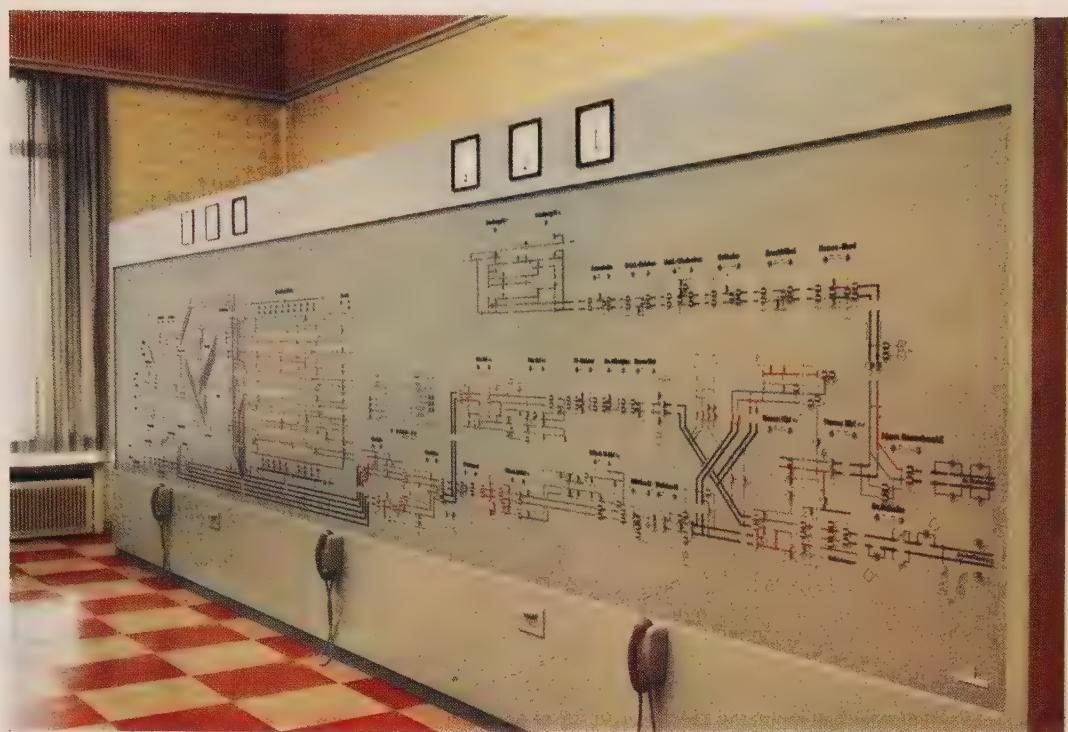


Fig. 3 Control board of the mosaic type for a railway junction

isolator via the indication uniselector of the substation in question. This impulse train also contains the position indications of all switches of this group. In contrast to the control impulse train, however, it does not contain a long-time starting pulse as a criterion and does therefore not cause the receiving uniselectors of the other substations to operate. It is only evaluated by the indication receiving uniselector at the control point and is used for the position indication of the respective switch on the mimic diagram. At the same time, the indication impulse train locks out the indication uniselectors of the other substations so that mutilation of indications is prevented.

Since the control cable is run parallel to the track there is no definite guarantee that interference will not be induced in the pilot cores, resulting in an occasional mutilation of the indication impulse train. The Siemens-Schuckertwerke remote-control uniselector equipments therefore have an automatic general high-speed check which immediately calls for a repeat signal on receipt of a mutilated indication impulse train which cannot be evaluated.

In the case of supervisory control of mast switches it is not generally possible to initiate the position indication via an unoccupied auxiliary switch contact as in the case of the remote control of substation breakers. The limit switches of these breakers, which are generally equipped with a motor-driven operating mechanism, are connected into the control circuit and are not therefore available for direct connection to the uniselector equipment. For this

reason, separate power auxiliary relays are required which are interposed in the motor power circuit and whose contacts switch into the selector unit circuit. Such interposing relays are also required in the direction of control for supplying the necessary driving power. The contacts of these auxiliary control relays are arranged in parallel with the operating switches of the local control board, which is nowadays of the space-saving light-current type and is located in the station signal cabin, if any, or in the station building.

The mast switches of the individual sections are remotely controlled from area control stations which are usually located at the railway junction stations. The line sections, radiating from these area control stations, are remotely controlled and supervised for a length of 50 to 60 km. The substations or switching stations along the line can also be included in the centralized control system. Recently there has been a pronounced tendency towards considerably extending the range of the area control stations in order to reduce the number of personnel required.

For the remote control and supervision of the individual line sections either control desks or wall boards with a simple route diagram are installed. The interrelation with the exact line points is indicated on a comprehensive track diagram above the route diagram (Fig. 2). This shows the individual tracks of each route in the same code colour as the associated route on the electrically-lit track diagram.

To enable the operator to tell at a glance which track sections are rendered dead in the event of operational disturbances or repair work, the route sections are not shown in the form of a mimic diagram but as an electrically-lit route diagram. The dead track sections are caused to light up by an additional relay combination.

The individual breakers or isolators are remotely controlled and supervised by means of control discrepancy switches. Any changes in position are indicated by the flashing of the knob lamps of the associated control discrepancy switch unless pre-acknowledged by the initiation of a preceding control signal.

Control boards of the mosaic type (Fig. 3) [6] are being installed on an ever-increasing scale in the area control stations. The mosaic type of construction makes possible easy adaptation of the control board to changes in the power system or route diagram to be expected in the majority of installations. This simple extension facility also offers great advantages in the case of extensions or the addition of new lines with supervisory control equipments.

The supervisory control equipments described above are indispensable for trouble-free operation of railway trac-

tion power supply systems. In the most varied undertakings of this type in Germany, Europe and overseas Siemens-Schuckertwerke supervisory remote-control and indication systems are used for the following tasks:

- Supervisory remote control and position indication of approx. 7,000 circuit breakers or mast switches
- Position indication of a further 600 switches
- Transmission of approx. 3,300 alarm and earth-fault indications and standard instructions
- Selection of approx. 700 remote meter readings.

All these supervisory control functions are performed dependably and free from faults.

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NEW EQUIPMENT

Aluminium-sheathed Railway Feeder Cables

BY FRIEDRICH RADEMACHER

One of the most important requirements in the operation of electric railway systems is the reliability of the power supply. In the design and manufacture of railway feeder cables for connecting the substations to the overhead contact wire the cable manufacturing industry has to give full consideration to this demand.

For use in single-phase a.c. railway systems Siemens-Schuckert manufacture single-core aluminium-sheathed cables (Fig. 1) the sheath of which is employed as the earthed return conductor. The cable core is constructed in conformance with the Specifications of the Association of German Electrical Engineers VDE 0255. At rated voltages of 10 kV and upwards the ordinary round multi-strand conductor is replaced by a special conductor. This compressed type of conductor prevents the migration of compound through the spaces between the individual strands when the cable is installed on steep slopes or used as a lead up to overhead supports.

When used as the return conductor, the aluminium sheath must be so dimensioned that its conductance is equal to that of the main conductor. Since sheaths as laid down in VDE 0286/10.56 (specifications for metal-sheathed power cables for experimental purposes) are not sufficiently thick in the case of single-core cables, the cross-section of the sheath is increased by a layer of flat aluminium wires applied over the cable core. This is followed by the seamlessly extruded aluminium sheath. Even where installation conditions are



Fig. 1 Paper-insulated railway feeder cable. An aluminium sheath and flat aluminium wires serve as the return conductor

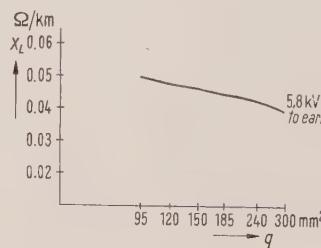


Fig. 2 Inductive reactance X_L of railway feeder cables at $f = 50 \text{ c/s}$

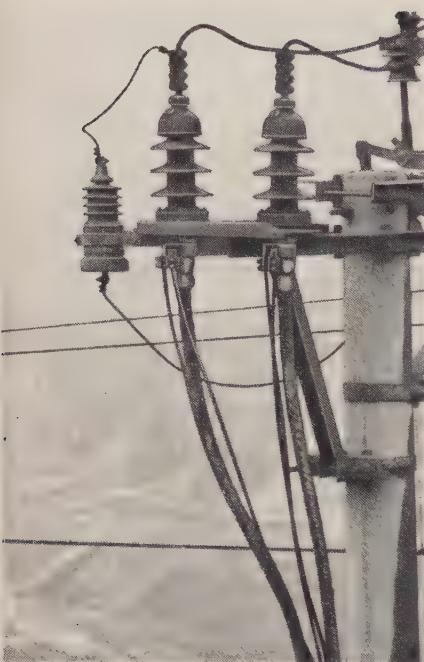


Fig. 3 Outdoor sealing end for railway feeder cables with concentric conductors

difficult, armouring is not necessary since the aluminium sheath reinforced by the layer of flat wires is adequately strong. A further advantage is its insensitivity to vibration. Aluminium-sheathed cables can therefore be used where stresses of this nature are produced, as is the case, for instance, on railway embankments and bridges, without special measures having to be taken.

In view of the fact that the life of an aluminium-sheathed cable is very much dependent on proper corrosion protection, Siemens-Schuckert also provide railway feeder cables with a multi-layer protection of thermoplastic tapes having a base of polyisobutylene and with an outer PROTODUR* sheath. The selection of the wall thickness is determined not only by the required mechanical strength but also by the possible overvoltages to earth in the event of a fault, particularly in the case of long cable runs.

In electric traction operation, high overload peaks occur which may momentarily exceed the rated current by as much as 30%. The conductor cross-section is not, however, dimensioned according to the load peaks but is determined by a constant load which produces the same temperature rise as the fluctuating load. Railway feeder cables with concentric return conductors have a slightly higher current carrying capacity than single-core lead-sheathed cables which are laid parallel in a trench with 1-kV PROTODUR return cables. This provides a greater reserve for momentary current peaks.

Fig. 2 shows a graph for the inductive reactance of railway feeder cables at voltages of 5.8 kV to earth and a system frequency of 50 c/s. The low value results in a small voltage difference between no load and full load which is particularly advantageous where the feed-in points are located some distance away from the substation.

On overhead supports, concentric railway feeder cables are terminated by outdoor sealing ends with a porcelain insulator (Fig. 3). They are distinguished from the type used for single-core cables of conventional design by a copper entry gland, which is soldered to the concentric conductor, and by the additional

corrosion protection provided at this point. The return circuit between the sealing end and the rail is completed by single-core PROTODUR cables. For the terminations in the substations sealing ends without compound (EoV) and with a copper cap are used. In the case of junction boxes, the housings are made of copper to which are soldered the aluminium sheaths and the flat aluminium wires thus jointing the return conductor. After installation, the junction boxes are provided with layers of impregnated tape as protection against corrosion.

Aluminium-sheathed railway feeder cables afford economic as well as technical advantages. For a voltage to earth of 5.8 kV, for instance, an aluminium-sheathed cable is approximately 20% cheaper than a comparable single-core lead-sheathed cable with a 1-kV thermoplastic cable as the return conductor.

Feeder cables with aluminium sheaths have been in service for more than five years and have found particularly wide application in the Rhine-Westphalian lignite areas where they ensure a trouble-free power supply to the mine railways, in many cases under difficult and arduous conditions.

Austria's New Transit Office

BY ODO MAYER

The inauguration of the new transit office in Vienna was an important step in linking the Austrian telephone network with the international dial service network. The first calls to be dialed through this office were made in July 1960 on circuits linking Austria and England. Shortly afterwards circuits between Vienna and the transit offices in Frankfort, Brussels and Copenhagen were placed in service. In the near future the Swiss telephone network will be accessible through the Zürich transit office (Fig. 1).

Vienna's transit office handles not only calls originating in Austria and calls dialed into Austria from abroad, but also transit calls between dial offices abroad. Calls destined for abroad are at present first set up semi-automatically by operators at the long-distance switchboard of Vienna's long-distance office.

For transit and automatic indirect routing, where various prefixes have to be repeatedly processed and retransmitted, speed is of major importance in the transmission of dialing information. Dialing information is for this reason transmitted over the international trunks with the aid of a 2 VF binary code. Fig. 2 shows a frame containing 2 VF signalling equipment. At the top and bottom of the frame there are three relay repeaters with associated 2 VF receiving tubes; the switching panels in the middle are for measuring and testing.

In contrast to pulse dialing, each digit consists in the case of 2 VF dialing of a 4-element combination composed of the two frequencies 2040 cps and 2400 cps. One of the two frequencies is transmitted for each of the four elements. The code comprises the digits 1 through 0 (10) and the numbers 11 through 15. Code 11 gives access to an operator at the wanted dial office; code 12 gives access to a certain switchboard position in the same long-distance office.



Fig. 1 International trunkgroups of Vienna's transit office

* Trade-mark

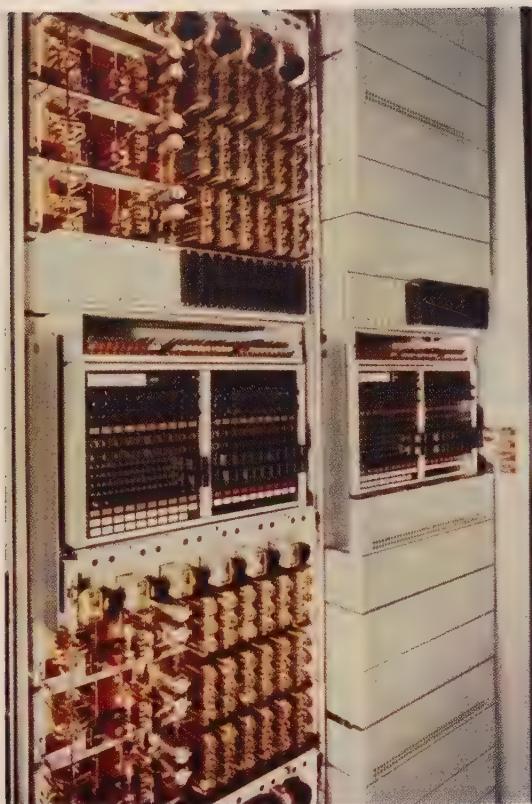


Fig. 2 Frame with 2 VF relay repeaters



Fig. 3 Central electronic translator for 2 VF dialing

Codes 13 and 14 are at present unassigned; code 15 is used by Vienna operators to indicate completion of dialing and that no further digits will be sent. The 15-digit keysenders used by operators are wired for the transmission of binary code signals.

The pulse trains are encoded, decoded, and stored in registers that are connected to the trunks only for the time required to establish the connection. Registers are referred to as originating registers, transit registers or terminal registers in correspondence with their functions. Relay finders embodying high-speed noble-metal relays¹ switch the registers to the 2 VF relay repeater assigned to each trunk.

The switch room of Vienna's transit office is equipped with the same motor uniselectors as are used in Austria's long-distance dial service network. Assigned as 1st and 2nd international route selectors, they establish 4-wire connections to international trunks, to the Austrian network, and to switchboard positions of the long-distance office. The international route selectors are operated by control sets that draw their information from a central translator by way of the registers (Fig. 3). For controlling the route selectors the translator determines the route code from

the national prefix that has been dialed. The translator performs this operation exclusively with the aid of electronic components.

In the case of international calls terminating in Austria, the local prefix and directory number of the wanted Austrian subscriber are fed in the terminal register to a magnetic core array. The multistable units of this memory are magnetized to a greater or lesser degree according to the digit to be stored. The transit office equipment is adapted to the Austrian dial system by relay repeaters developed and manufactured by the Austrian Siemens Company. The motor uniselectors already mentioned are also made in Austria. All the other facilities are designed conforming to the dial system technique of the German Siemens organization and operate in the same way as the equipment in Frankfort's international switching center². Long-distance calls are handled conforming to CCITT recommendations aimed at standardizing dial service on international trunks.

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2 Adler, R. and Bretschneider, H.: Frankfort International Telephone Switching Center. Siemens Review XXVII (1960) pp. 21 to 25

For cutting out and pasting on index cards



EBERHARD WOLFROM

**Gandhi Sagar —
a New Hydroelectric Power Station in India**

5½ pages, 3 figures

Siemens Review XXVIII (1961) pp. 183 to 188

Within the framework of the scheme for regulating the River Chambal three new hydroelectric power stations are being erected in the north-west of India. The first, Gandhi Sagar, is designed for a total output of 92 MVA and will be commissioned in the late summer of 1960. A description is given of the design and equipment of the three 23-MVA vertical-shaft generating units with Voith/Francis turbines and Siemens-Schuckert umbrella-type generators. The equipment includes a modern excitation system employing a magnetic-amplifier voltage regulator fed from a main shaft-mounted auxiliary generator.



U.D.C. 621.395.65

JOHANN-FRIEDRICH FRANZEN AND HEINZ VOGEL

Illuminated Buttons for Indication and Switching

3½ pages, 7 figures,

Siemens Review XXVIII (1961) pp. 188 to 192

Our line of illuminated buttons includes spring-loaded and locking type pushbuttons, rotary buttons, rotary push-buttons, and magnetic buttons with built-in indication lamp. A variety of combinations, small mounting dimensions, and clear button identification permit the construction of functional control panels of any type and size. The structural design and features of the different models are described and typical applications outlined.



U.D.C. 621.315.221.7:669.71 :621.315

FRIEDRICH OTTEN AND LOTHAR HEINHOLD

**Experience gained with Aluminium-sheathed
Power Cables**

4 pages, 6 figures, bibliography

Siemens Review XXVIII (1961) pp. 192 to 196

Paper-insulated aluminium-sheathed cables, which are the result of long and painstaking development work, have proved their worth in the field. They fully meet all safety requirements and, by reason of their low weight and price, are frequently used in urban networks. Only in a few instances has there been any damage by corrosion, this being the result of mechanical damage to the corrosion protection or of flaws. The mechanically reinforced multi-layer corrosion protection with a Protodur outer sheath which is now generally employed should reduce the possibility of such damage to a minimum.



U.D.C. 621.315.221.7:669.71:621.39

RUDOLF ZÖCKLER † AND NORBERT ODEMAR

Aluminum-Sheathed Communications Cables

3½ pages, 3 figures, bibliography

Siemens Review XXVIII (1961) pp. 196 to 199

Since the advent of aluminum as a metallic sheathing material for cables, lead has had to stand up to considerable competition. Instances of the application of communications cables are described where the use of aluminum sheathing represents the optimum technical and economic solution available at the present time. Aluminum sheathing is widely used for communications cables wherever it is necessary to overcome serious disturbance due to outside electromagnetic fields.



SIEMENS

U.D.C. 621.316.718:621.771.232

OTTO MARTIN, CLAUS SCHENDEL AND HANS SEYFRIED

Control of the Twin Drives of a Plate Mill

3½ pages, 5 figures, bibliography

Siemens Review XXVIII (1961) pp. 200 to 203

With the aid of a block diagram a description is given of the control of a mercury-arc rectifier fed twin drive for the four-high stand of a 4.2-m plate mill. A description is given of the technological problems encountered and of the methods by which they were solved. The article includes illustrations of the plant and several oscillograms for electrical values.



U.D.C. 621.394.34:656.7(493)

SERGE LEBRUN

Development of the SABENA Teleprinter Network

2 pages, 3 figures

Siemens Review XXVIII (1961) pp. 203 to 205

Since the earliest days of railroads and air traffic, telegraphy has played a vital role in the transmission of messages. The Sabena, like other airlines, has constructed its own telegraph network. In line with technological progress, manual message-handling has here been superseded by semi-automatic operation. In March 1961, SABENA placed in service a fully-automatic switching center which also meets the exacting requirements imposed by jet planes.



U.D.C. 621.394.34:656.7(493)

WINFRIED GRAF

**The Teleprinter Switching Center of the SABENA
for Fully- and Semi-Automatic Operation**

5 pages, 5 figures

Siemens Review XXVIII (1961) pp. 205 to 210

In the teleprinter networks of airlines, most messages do not require a reply and many are addressed simultaneously to a number of destinations. Message switching centers lend themselves particularly well to this purpose. In March 1961 the first center of this type designed for fully-automatic operation was taken in service by the SABENA in Brussels. The operating principle and message flow are described.



U.D.C. 621.398:621.331

WALTER HENNING

**Supervisory Remote Control and Indicating
Equipment for Traction Power Supply Systems**

4 pages, 3 figures, bibliography

Siemens Review XXVIII (1961) pp. 210 to 214

To ensure the reliability of the power supply for traction systems appreciable use is made of remote control and indicating equipment. On electrified railways this makes possible the remote operation of unattended substations and area control stations and also the remote control of section switches. The control boards are generally arranged at junctions and are usually provided with luminous indication of the section conditions. Supervisory remote control and indicating equipment is also employed in the load dispatching stations of extensive railway-owned extra-high-voltage systems.



For cutting out and pasting on index cards



U.D.C. 621.315.221.7:669.71:621.332.21

FRIEDRICH RADEMACHER

Aluminium-sheathed Railway Feeder Cables

1 page, 3 figures

Siemens Review XXVIII (1961) pp. 214 and 215

The use of single-core aluminium-sheathed cables of the power supply of the trolley system of industrial railways affords both technical and economical advantages. Reinforced by flat aluminium wire, the aluminium sheath serves as an earthed return conductor. Aluminium-sheathed railway feeder cables are distinguished by a low inductive reactance and therefore have a higher current-carrying capacity than single-core lead-sheathed cables with a 1-kV cable as a separate return conductor. They have given satisfactory service under adverse operating conditions for over five years.



U.D.C. 621.395.722(436.14)

ODO MAYER

Austria's New Transit Office

1½ pages, 3 figures

Siemens Review XXVIII (1961) pp. 215 and 216

With the inauguration of Vienna's new transit office in June 1960 Austria has joined the international long-distance dialing network.

The operating principle of the equipment installed in the transit office is described. Calls are handled conforming to CCITT recommendations.

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